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EARLY ENGLISH LOCOMOTIVES.

A RECENT number of *Engineering* gives illustrations, which we copy, of two early English locomotives which were exhibited by models at Chicago. Fig. 1 shows Trevithick's tramway engine. The model was made at Crewe Works, and is an exact representation

of the engine as built in 1803. It weighed in working order 5 tons, and took a gross load of 25 tons at a speed of 4 miles an hour over a bad road, with sharp curves and stiff inclines, and without a load it is reported to have run at a speed of 16 miles an hour.

Fig. 2 shows a full sized model of the "Rocket." The model was made at Crewe Works, and represents

the original engine as it appeared when competing for the prize of £500 offered by the Liverpool and Manchester Railway Company, at Rainhill, in 1829. The engine weighed in working order 4 tons 3 cwt.; it ran at the rate of 12½ miles per hour with a load equivalent to three times its own weight, and when taking a carriage and passengers it traveled 24 miles an hour.

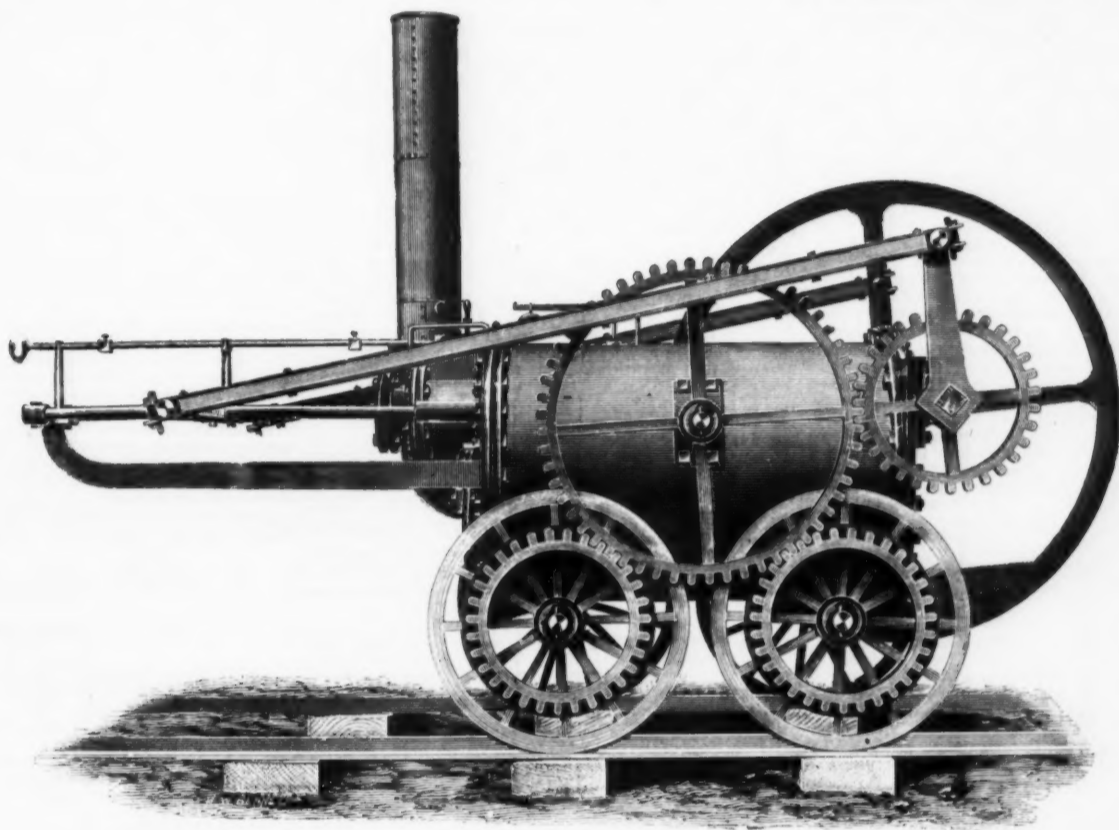


FIG. 1.—MODEL OF TREVITHICK'S TRAMWAY LOCOMOTIVE, 1803.

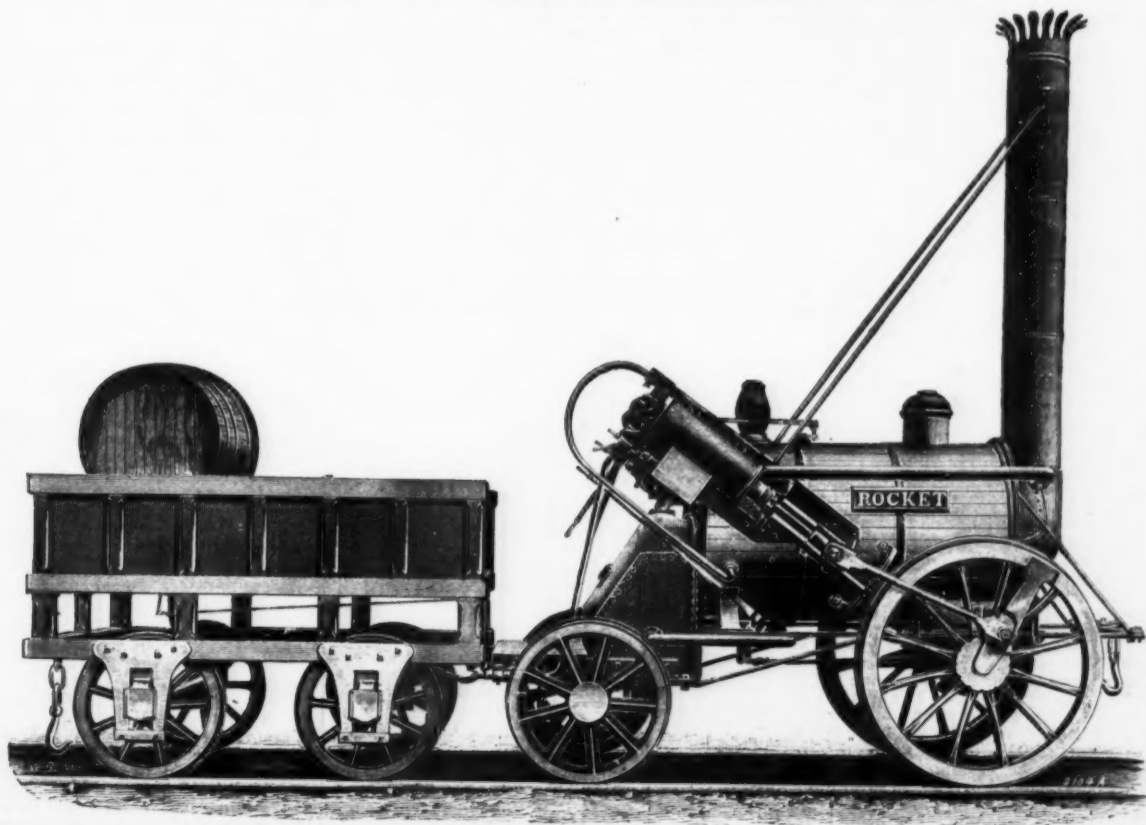


FIG. 2.—MODEL OF STEPHENSON'S "ROCKET," 1829.

WATER TUBE BOILERS.*

We propose in a short series of articles to explain the principles involved in the design and working of water tube boilers; the conditions which, for various purposes, they ought to fulfill; and the constructive arrangements most likely to satisfy these conditions. We do not intend to supply historical information. It is not our purpose to describe in detail any boiler or method of construction. Our criticisms must not be taken as directed against any particular make of boiler. What we shall have to say in favor of a system or systems must be regarded as wholly impersonal. In other words, having laid down certain principles to be observed in designing water tube boilers, our standard of merit will be based on the extent to which these principles are observed.

In the present day steam is always generated either in cylindrical vessels or in flat-sided chambers the plates of which are stayed together. The locomotive boiler supplies an example of both methods of construction. The fire box and its casing are flat-sided stayed structures. The barrels of the boilers are cylindrical vessels. The water tube or tubulous boiler differs from others principally in the size of the tubes. But it must not be forgotten that many types of water tube boiler have cylindrical vessels of very considerable dimensions as component portions of their structure, while in others flat-sided stayed chambers are used.

Seeing that boilers of the Lancashire, Scotch, and locomotive types give excellent results, it may legitimately be asked why the water tube boiler should supersede them. The question admits of several answers. The principal are: (1) That the water tube boiler is safer at heavy pressures than any other. (2) That it is much lighter. (3) That steam can be got up more quickly in it; and lastly, that it is more portable, in that it can be conveyed from place to place in portions or sections, easily handled, and of very moderate weight. It may be taken as certain that the water tube boiler is not more economical than other forms of steam generators, assuming of course that we select favorable examples of each type.

Almost all inventors of water tube boilers have started with the fundamental proposition that good water circulation is to be obtained at any cost. It is, however, a remarkable fact that most erroneous opinions are held concerning circulation and its cause, even by those who ought to be very well informed on the subject. As a matter of fact, however, it can be shown that circulation is not necessary; that it cannot be avoided, and that it is always to be considered simply in the light of an evil. Circulation is due to two causes. The first of these is difference of density in two portions of a body of water, the difference being due to diversity of temperature. If the water throughout a boiler is all of the same temperature, there will no longer be circulation from this cause. In Fig. 1 circu-

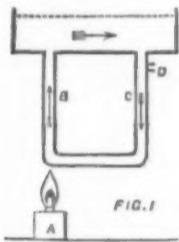


FIG. 1

lation will take place in the direction of the arrows when the lamp, A, is placed as shown, but only so long as the water is becoming hotter. As it gets nearer and nearer to 212°, the circulation will become slower and slower. It is no longer possible to make the water in B any hotter; but C may be kept colder, as by a current of cold air, and circulation will then go on—but only because a portion of the water is kept below the temperature proper to the pressure at which the rest of the boiler is generating steam. The principle has been extensively employed by many inventors, and in some cases the cold feed has been delivered somewhere about the point, D, in order to keep down the temperature still further. A little reflection will show that so long as water is kept in contact with a heated plate or tube, it matters nothing whether that water is circulating or not; it will absorb heat and give off steam; but care must be taken that the steam does not drive away the water. It is because it has driven away the water that so many water tube boilers have turned out more or less disastrous failures. It is before all things necessary for those designing water tube boilers to have perfectly pellucid views on the subject of circulation. Lacking this, it is quite impossible for them to attain success. Now, the simple rule to be observed is this: "Take care of the steam, and the water will take care of itself." That is to say, the boiler must be so constructed that accumulations of steam in one portion may not force the water out of that into another portion. That is what took place in the historical boilers of the s.s. *Montana*. The tubes out of which the water was driven became red hot and burst. Furthermore, it must be remembered that different portions of the boiler are exposed to different intensities of heat, and the steamway which may be large enough to clear the tubes in the cooler portions may be altogether inadequate to clear those in the lower portions. Thus, for example, the steamway which may suffice for A, Fig. 2, may not be great enough for B, the ultimate delivery from which into C is hampered by the discharge from all the pipes above it into D. If a boiler of this kind, wrongly proportioned, is worked quietly it may do very well. If it is forced, B will be emptied, the water being driven back into E. If the fire is very fierce, the lower tubes may be ruined in this way; if not, then water will be taken by gulps into B, and the result will be unsteady working, and priming more or less severe. This is a principal reason why the numerous class of boilers with long pipes and deep "headers" have proved themselves unfit for forcing. They answer very well with moderate draught and an evaporation at the rate of about 2½ lb. to 3 lb. of water per square foot of heating surface per hour. For higher

rates they have to be specially proportioned; but under no circumstances are they suitable for the very highest rates, such as those obtaining in torpedo boats.

It is erroneously held by many persons that circulation takes place after ebullition has commenced, under such conditions as those indicated in Fig. 1, because the leg, B, contains steam and water, while the leg, C, contains water only; and even so eminent an authority as the late Mr. Babcock maintained that the maximum useful circulation was obtained when the contents of the ascending leg weighed just one half as much as the contents of the descending leg. This implied, of course, that the bubbles of steam in the former must be equal

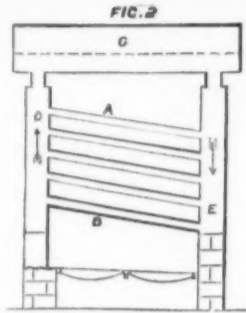


FIG. 2

in volume to the volume of water in the leg. There is no foundation in fact for this theory. If it were true, it would suffice to displace half the water in the ascending leg with corks to get circulation with cold water. Those who hold the same view as did Mr. Babcock forget that the pressure of water is a function of the head and not of the mass; and so long as the head of water is the same in B as it is in C, it matters nothing what may be suspended in B, there will be no circulation. This is very clearly proved by the aid of bent glass tubes, provided they are not too small in diameter, when an action takes place to which we shall refer by and by. If the experiment is properly carried out, a continuous upward rush of steam bubbles may be maintained in one, while there is practically no movement of the water. We have no doubt that in some forms of water tube boiler there is no circulation of the water worth mentioning. Indeed, the only arrangement maintaining circulation, consisting of an external down pipe, has been removed, and the boiler has in no way suffered. As a rule, however, in all water tube boilers there is circulation of water, and in some it is exceedingly violent and rapid. We have yet to consider to what this circulation is due. This we shall endeavor to explain hereafter. Before doing this, however, it is well that our readers should be in no doubt concerning the unequal density argument. It will be made clearer by Fig. 3. Here, in the

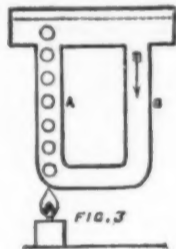


FIG. 3

ascending leg, are seen a number of steam bubbles, which, of course, displace a certain volume of water. If now it were possible to weigh the contents of A and B, it would be found that the former was much the lighter. This being so, it is held that water flows from B to A. It seems sufficient to state the case to show its absurdity. We have already pointed out that corks might take the place of the bubbles in cold water, but no one dreams of saying that circulation would take place in very many if not in most water tube boilers then. The case stands thus: The temperature of the water is very nearly the same in both A and B. Not infrequently the difference is not one degree. No circulation worth the name can then be produced by difference of water temperature. Again, the head is the same in A and B, or, rather, it is higher in A than B, so that circulation cannot be due to the difference in height of the contents of the two legs. In connection with this point, we reproduce an account of an experiment carried out in the United States, by Mr. Hogan, the patentee of a water tube boiler. Fig. 4 shows the experimental boiler. The

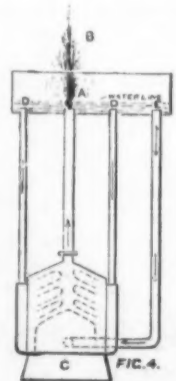


FIG. 4

pipes and boiler were filled with water to the water line, and the water was gradually heated until the fire was in good condition. The fire was then forced, and in a few minutes water and steam were thrown upward from A to B some 20 feet. The distance from C to A was 18 feet.

It will, we think, scarcely be maintained that this

action was due to the difference in weight of the columns of water, C A and E F. So long as the theory is maintained and acted upon, that a difference in the weight of the contents of the rising and falling columns is the cause of circulation, so long will faulty methods of construction be adopted. It is because that by either accident or as a result of sound knowledge the theory has been ignored, that important advances have been made in the construction of tubulous steam generators.

Before proceeding further, it may be worth while to explain the reasons why the erroneous theory of circulation which we set forth formerly has been accepted. It appears to be based on the results of experiments made with small glass tubes. We have already called attention to the misleading nature of such experiments. If, instead of a tube one inch or a little more in diameter, we use a tube with a bore of a quarter of an inch or thereabout, it is very easy to carry out an experiment in such a way that there will be no true hydrostatic head in the rising pipe. What takes place is shown by Fig. 5. Here we see bubbles

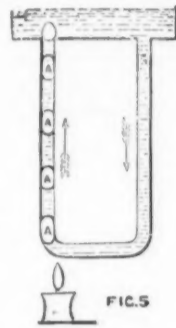


FIG. 5

of steam, A A, etc., following each other up the rising leg. Each bubble quite fills the bore of the tube, and circulation will in that case be due mainly to the difference in weight of the contents of the two legs. In practice, however, the steam bubbles hardly, if ever, fill the diameter of the tube, and all that we have said in our last impression holds good.

We have said that circulation, sometimes very violent in character, takes place in water tube boilers. We have now to explain to what that circulation is due. The cause of circulation, that is to say, of the movement of the water in the boiler, can be very briefly stated. The explanation of the working of the cause in detail will occupy a little space, which may very advantageously be devoted to it. The water is made to move by the movement of the steam. A very simple and satisfactory way of demonstrating this is to substitute air for steam.

There can be no question then of heat having anything to do with the matter. Fig. 6 will serve to illus-

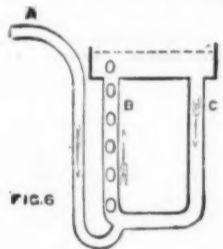


FIG. 6

trate our meaning. The apparatus being filled with cold water in which a little sawdust is suspended, it is only necessary to blow into the tube, A; a constant stream of bubbles will ascend through B, and these will set up a rising current, while the water will descend in C.

The velocity with which a steam bubble would ascend would be enormous but for the resistance of the liquid through which it moves. The weight of a cubic foot of steam at atmospheric pressure may be regarded as next to nothing, but inasmuch as it displaces, when in water, a volume weighing 62½ lb., it follows that the force urging it to rise is 62½ lb. Now, the acceleration due to the action of gravity is equal to 32 ft. per second. That would be the velocity acquired by a "mass" weighing 62½ lb. on which was impressed a force of 62½ lb. But in the case of our cubic foot bubble of steam, there is practically no mass, while there is still a force of 62½ lb. acting. Let us, for the sake of argument, assume that the bubble of steam weighed one pound; then the buoyant force being sixty-two and a half times that of gravity, the bubble would acquire in a second a velocity = $32 \times 62\frac{1}{2} = 2,000$ ft. per second, and would traverse in that time a space of 1,000 ft. Of course, no such velocity as this is ever attained, because we have the very great resistance of the water retarding the bubble.

There is, besides, another and important action to be considered, which modifies the velocity of the ascending bubble. Let A—Fig. 7—be a tall vessel containing

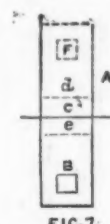


FIG. 7

water. At the bottom is a hollow empty box, of one cubic foot capacity. Let this box be retained at the bottom by a cord or other expedient. The center of gravity of the body of water in A will then lie somewhere above the middle line C, let us suppose at d. If now the cord is cut, B will rise to the top and take the position shown by the dotted lines, E. But B can

* From the Engineer, London.

rise only by virtue of the center of gravity of the whole mass of water in A falling, say, to e , and the velocity with which A rises is ultimately limited by the rate at which the center of gravity can fall. But a little reflection will show that the cross section of the mass of the water, or, rather, the relation of the mass of the water to that of the space represented by the box, B, has an important influence. Thus it will be seen that while B has to rise to F, the center of gravity of the contents of A has only to fall from d to e . The only importance which this fact has in connection with water tube boilers is that the larger the descending waterway the greater, other things being equal, will be the velocity at which a bubble will ascend.

Popularly speaking, bubbles of steam "float" to the top; but they acquire almost at their first formation a high ascensional velocity. We have for the sake of simplicity spoken of the bubbles as nearly without weight, but especially when we have high pressures, the steam bubbles really have an appreciable weight. Thus steam with a total pressure of 175 lb. weighs 0.39 lb. per cubic foot. Thus each bubble has momentum. It may be said to start, to begin with, at a high velocity, and from first to last it is kept back by the water through which it is moving. It pushes this water before it, and the result is an upward current, which, as far as the water is concerned, is not opposed by any resistance save that of the friction of the tubes and passages. If, then, as we have said, we take care to give the steam sufficiently good means of escape from the place where it was made, no evil consequences can ensue, no matter how much the boiler is forced; there will always be water ready to take the place of the steam.

It is by no means easy to make the action of steam and water under the conditions present in a water tube boiler intelligible to those who are unable to distinguish mentally between "mass" and weight. We believe, however, that we have said enough to make it clear that the velocity with which a bubble of air or steam will rise in water would be enormously greater than the rate at which an equal mass of matter would fall in air, were it not for the resistance of the water. On this point it is worth while to quote Mr. Krauss, of Vienna, who, writing on circulation in water tube boilers in an American contemporary, *Power*, says: "If the surface of the water is $4\frac{1}{2}$ ft. above the steam bubble, the velocity of the bubble at the moment of striking the surface of the water will be 246 ft. per second, friction and other resistances in pushing aside the surrounding body of water being neglected." In this calculation the weight of the steam bubble and of a body of water the same size as the steam bubble are taken into consideration.

Mr. Krauss continues: "But it is a condition that the surrounding body of water may be pushed aside. If this is not the case, and a vertical tube be put over the steam bubble, it is seen that the bubble when rising must raise the column of water above it as well as that beneath it. The potential energy necessary may be supposed to be furnished by another and neighboring column of water. If the tube with the bubble is closed at the lower end, no movement can take place, the potential energy having no opportunity to change into kinetic energy. If the bottom of the tube is only partly closed, the movement of the column will be much slower than when the whole area is open."

In practice the velocity with which the steam bubbles ascend is, as we have explained, controlled and limited by the friction and resistance of the water. Unless the steam can get away as quickly as it is formed, it must accumulate; but steam and water cannot be in the same place at the same time, and if steam takes the place of water in a generating tube, then that tube will be overheated. The deduction to be drawn from all that we have said is that, to all intents and purposes, steam will invariably get away in any vertical tube so fast that overheating is impossible if only the steam is given fair play. Thus, for example, if we take such a model as that shown in Fig. 1, making the whole affair of tin plate put together with soft solder, the lamp may be replaced by the fierce heat of a smith's fire, without melting the solder, provided care is taken to prevent the emptying of the whole apparatus by the water being thrown out. In one word, the essential point in a water tube boiler is to facilitate the escape of the steam from the generating or heating surfaces.

So far it will be seen that we have dealt only with the motion of steam and water in vertical tubes or pipes. But a very large number of water tube boilers generate steam in inclined tubes. The inclination is given because a bubble of steam will run to the higher end in precisely the same way that a bubble of steam runs to the higher end of a spirit level. Those who have followed what we have said so far will now see without further explanation that the velocity with which a bubble traverses an inclined tube must be less than that with which it traverses a vertical tube, unless some other agency than the slope of the tube is brought to bear.

What these agencies may be we shall consider later on. Our readers will not, however, be slow to perceive how important it is that "headers" or "risers" in boilers of this type, through which the steam ascends to the receiver or drum above, should

should be made as in Fig. 8. Constructive difficulties interfere, however. The tube ends become more or less inaccessible, because of the guide plates, A A, and certain other disadvantages are incurred. But nevertheless it is certain that we have here the elements of construction for a boiler that will bear forcing without priming.

If our readers will turn to Fig. 5 they will see that so long as the current is constant, or nearly so, in the rising limb, it must be constant throughout the whole length of the pipe; and it matters nothing what the length of the horizontal portion of the pipe is, water will flow through it for the sufficiently obvious reason that if it rises in one leg it will descend in the other, and consequently must move along the horizontal portion. That is to say, if we get the water to move in any part of a tube, it must move in the whole. The only agency which could prevent this would be the formation of steam somewhere in the length of the tube, which could not get away, and would prevent the further advance of water from the rear or lower end.

Now, if we take any boiler of say the Root type, we find that each inclined tube is virtually provided with a rising and a falling leg in the shape of the "headers," one at each end, and those tubes which are lowest and nearest the fire have longer legs than those which are higher and further removed from it. In one sense this is right, for it might be reasonably expected that a better supply of water will be secured to the lower tubes, which most need it, because the upward and downward forces impelling the water along the tubes are, in some ill-defined ratio, the greater the longer the rising and falling tubes are. But in other respects the arrangement is defective, because, as we have already pointed out, numbers of tubes arranged above each other debouch into the header; and the rush of steam and water from the lower tubes is hampered by the rush from those above. But this is not all. When boilers of this kind were first made, it was assumed that they would give beautifully dry steam; and no steam receiver or separator, save a tube which was little more than an enlargement of the steam pipe, was provided.

But as experience was gained, it was found that very large steam drums must be added, and we find such boilers fitted now with one or even two drums, 3 ft. or even 4 ft. in diameter, and 10 ft. or 15 ft. long. These are about half full of water. It was a favorite argument for tubulous boilers, that inasmuch as there was no vessel of large diameter holding a great deal of steam and water, they were safety boilers in the full sense of the term. Obviously, the use of this argument is incompatible with the presence of one or two great receivers, and consequently we seldom or never hear anything about "safety boilers" now. Early in this article we stated that circulation in a water tube boiler was a necessary evil. It is necessary in the sense that it cannot be avoided; it is an evil in the sense that it is the cause of priming. No doubt it may be said that if the boilers were properly constructed the priming would not take place, but then certain structural difficulties would be incurred. It is now time to discuss this branch of the subject more fully than we have yet done.

If we examine most of the inclined tube boilers, we shall find that the "header" or "riser" communicates with the receiver above through a comparatively contracted passage or neck. For obvious reasons none of our sketches are intended to refer to any particular boiler. But Fig. 9 will explain what we mean by a

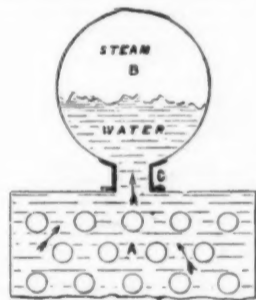


FIG. 9

contracted passage. A is the riser or header into which open the ends of the generating tubes. It is not remarkable that as the whole of the steam generated has to pass up through the neck, C, there is a violent uprush of steam and water quite thoroughly mixed, and a very considerable cubical space is required to give time for the water to fall away from the steam. The sketch in no way exaggerates the conditions in many boilers which we have seen. The result of the pretty free adoption of this method of construction has been the invention of a host of devices for getting dry steam. Of course prevention is better than cure, and if due care is taken to provide for the free delivery of the steam, there will be very little trouble from priming, which there must be so long as the steam has to rise through a great depth of water and escape through a small surface. To provide a free delivery for the steam, the neck should be entirely dispensed with and the risers worked into the steam drum in a way that will be very easily understood from the sketch, Fig. 10.

We are not aware of the existence of any boiler made in precisely this way, but we do not pretend to say they do not exist. But it is easy to see that the method of construction entails difficulties and is open to objection. Thus a boiler so made would not be eminently portable, because it could not be in the proper sense of the word sectional. As to first cost, it is possible that the reduction which might be effected in the size of the steam receiver would compensate in part, at least, for the extra outlay on construction; but on this point we are doubtful, because the plain cylinders with dished ends, which are used as separators, are, after all, about the cheapest possible expedients that can be made. But, furthermore, it will be seen that such a design entails a radical change in the whole method of construction. It would, in effect, mean a return to Dr. Alban's "heart," the tubes opening into a flat-

sided stayed chamber, instead of into sectional jointed "headers," often made of malleable cast iron, cheap and easily renewed. As it is absolutely essential that the tube ends should be accessible, doors or their equivalents must be provided; and these will be under pressure and must be jointed steam and water tight. In this circumstance lies one of the great differences between boilers with water inside the tubes and those with water outside them. In the latter we have only to make one set of joints—those between the tubes and the tube plates—tight. In the former we must make not only the tube ends tight, but the access doors as well, and the latter is the more difficult of the two. If now the design we have sketched in Fig. 10 were carried into practice, the front plate of the heart must either be fitted like the lid of a valve chest with studs and nuts, so that it could be taken off, or else it

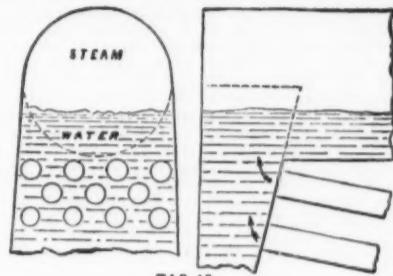


FIG. 10

must have as many, or nearly as many, holes as there are water tubes, fitted with doors, one opposite each tube, and, in addition, the flat sides would have to be stayed. The result would be, of course, that in a large boiler it would be nearly a day's work to get a front plate off to clean or replace perhaps only a single tube. However, boilers with removable plates were made by Dr. Alban with success, and they have also been tried in the United States, not, however, so far as we can learn, with much satisfaction. That is to say, such boilers have not become popular; they have not been a commercial success. We find that most makers build up the headers and deliver all the steam made through comparatively contracted necks and rely on the action of the receivers for getting the steam dried. That the result is, on the whole, satisfactory seems to be demonstrated by the popularity enjoyed by water tube boilers for electric lighting and other purposes on land.

But it must never be forgotten that such a method of construction is quite unsuitable for forcing. The effect of that is to drive such a torrent of water, mixed with steam, into the receiver that no subsequent manipulation will prevent priming.

We do not hold, however, that this is any disparagement of a very useful class of steam generator. On the Continent it has long held a high place in popular esteem. It permits the adoption of grates so large that any kind of fuel may be burned, even town refuse; and, provided the boilers are not hurried, they will give steam about equal in quality to that obtained from a Lancashire boiler. In this country we have not been content with this. We have tried to get more out of the boiler than it was ever capable of doing. We have attempted to win the Derby, so to speak, with a cart horse, and then we have fallen foul of the cart horse as though it were his fault. The result of pristine failures was that for many years the water tube boiler met with small favor in this country. We may digress here for a moment to say that we believe that it will be found advantageous to adopt a special name for water tube boilers which will stand forcing, and we do not think that a better word than "express" is available. Now, experience extending over many years has shown that no water tube boiler with long inclined tubes of large diameter can do "express" work; and to avoid all chance of being misunderstood on this point, we shall summarize the reasons why they cannot.

But in doing this we shall leave out of consideration all objections which might be urged against them, on the ground of their external characteristics; such, for example, as the necessity for placing them in brick ovens, their great length, etc., and confine ourselves to what goes on within them. The first objection is that the tubes being of considerable dimensions, say 4 in. diameter and 12 ft. to 15 ft. long, the qualities available in the market, although very good, are not good enough to stand for any lengthened period the tremendous heat due to forcing the fires. The second objection is that the tubes immediately over the furnaces are exposed to so high a temperature that they are bound to make an enormous volume of steam, and the length of the tube is so considerable, and the delivery of steam from it so hampered, that it never can contain much but froth when the fire is driven, and very great risk of burning and splitting the tube is entailed. In the third place, the delivery of steam from the tubes takes place through an area so contracted that priming can scarcely be avoided. Other arguments might be adduced, but after all they do not seem to us to be needed, for no one in the present day dreams of forcing boilers of this type. We have only referred to their unsuitability for the purpose, because they have been tried for marine purposes and failed, and because even now patents are constantly being taken out for boilers which are but modifications in detail of the Root or De Naeyer type, intended to adapt them for use at sea. The express boiler is radically different from the normal tubulous boiler. It is almost a new departure in boiler engineering, and we have now to consider why it does work that its predecessors cannot.

(To be continued.)

CYCLING IN RUSSIA.—The bicycle is but little encouraged in St. Petersburg. Wheelmen there are restricted to the use of certain streets, which are for the most part so wretchedly paved as to make riding through them almost impossible. No person under the age of eighteen may enjoy the privilege of cycling, and no very high machines are allowed in the streets. Another order provides that after dark no cycles of any sort shall be permitted.

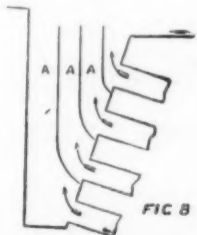


FIG. 8

be of ample dimensions. One reason why boilers of this type will not stand forcing is simply that these headers are too contracted in dimensions, while the bubbles are allowed to interfere with one another.

When boilers of this type are intended for driving or forcing, the header, or "heart," as Dr. Alban called it,

THE AUTOMATIC BALANCE OF RECIPROCATING MACHINERY AND THE PREVENTION OF VIBRATION.*

By W. WORBY BRAUMONT, M. Inst. C. E.

VIBRATION, set up by machinery of various kinds, has often given rise to problems of great difficulty, and the cause of the vibration has sometimes been as obscure as the phases of variation in its transmission have been mysterious. The character of the vibration differs with different classes of machinery and with the same machinery working at different speeds. It is intended in this paper to deal with a limited class of machines and to refer more particularly to those in which the essential parts reciprocate or gyrate at a high speed or not at a low speed. It is, moreover, intended to deal chiefly with machines in which the reciprocating or gyrating part receives motion from a source, and is not the source of rotation, as in steam engines, although brief reference will be made to vibration set up by the latter, and to its possible prevention. The tendency of any unsymmetrical mass to rotate about its center of gravity, and to rotate the axle or shaft upon which it is running round that center, when it is not coincident with it, may be prevented, by additions to the mass which move the center of gravity of the whole to the center of rotation. This simplest case, however, is frequently complicated in practice by the impossibility of placing the rotating parts in the same plane. Generally, the difficulties in connection with these cases are much less than those in which a motion of reciprocation or of gyration is imparted by means of a rotating part.

In almost all cases, motion of one or other of these kinds in the machinery now to be considered is effected by a crank shaft and connecting rod, or an equivalent of these; and, except where the crank has three or more dips connected by rods, which move reciprocating parts simultaneously in opposite directions, the perfect balance of such a crank and connected mechanism is very difficult and almost impossible.

In some cases, the use of a heavy fly wheel, with only as much unsymmetrical weight as will balance the

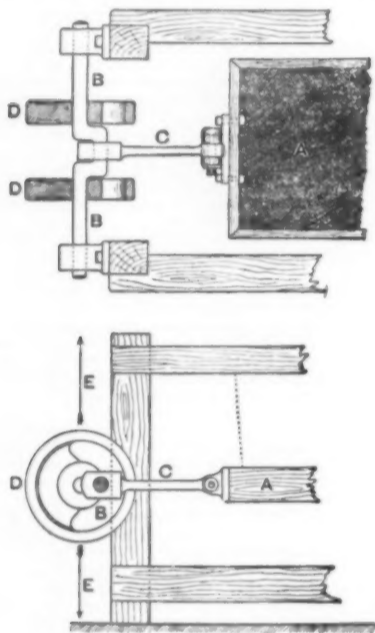


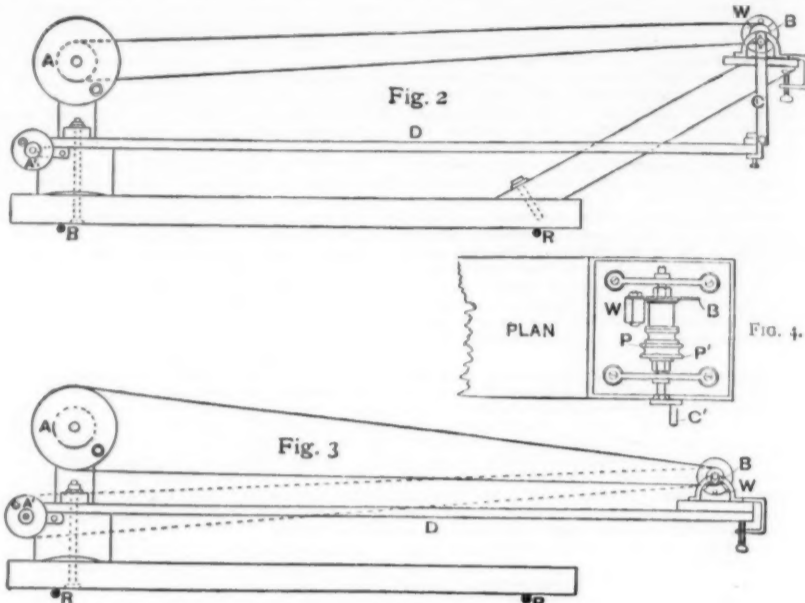
FIG. 1.

crank and the connected reciprocating parts, will approximate to this result; but the weight of wheel necessary to secure the smooth running of machines in which the main parts are reciprocated at high speed has numerous practical disadvantages, which generally precludes its use. It is common to balance, as it is called, the crank and connecting rod by eccentric weights, which frequently are very much heavier and at the speed of their rotation have momentum much greater than the parts supposed to be balanced. This is in consequence of the necessity for opposing the inertia of motion, not only of the crank and connecting rod, but of the heavy reciprocating part operated by the crank, and alternately its inertia of rest. This necessarily throws large stresses upon the crank shaft and its bearings, which form the abutment against which the pull and push of the crank acts and reacts. These bearings have to be—in all cases—fixed to the framing of the machine, part of which is to be reciprocated or gyrated, or to something which relatively to that part is at rest. The action and reaction resulting from the working of the machine is therefore, except in so far as it is balanced in one direction, transmitted to the framing of the machine, or the building foundation, or floor to which the bearings are attached. By the use of heavy eccentric weights on the crank shaft in the way mentioned, the effect of the push and pull on the connecting rod may, in the direction of motion of the thing reciprocated, be eliminated, but in the direction normal to this, a nearly equal action and reaction is experienced by the bearings in consequence of the influence of the rotating eccentric weight. This may be shown by reference to the diagram, Fig. 1, in which A represents the part to be reciprocated; B, the crank shaft; C, the connecting rod; and D D, eccentric weights, in the form of disks, heavy on one side. In the direction of the length of the part A, which may be a sieve of the several kinds used in flour mills, or a screen for crushed minerals, the inertia and momentum are equal, and are approximately balanced by those of the eccentric rotating weight, D, but in the vertical direction, as indicated by the arrows, E E, the work done by the weights, D, in balancing forces in a

horizontal direction is also done in the vertical directions, E E, by these weights, or, more correctly speaking, the vertical upward and downward force exercised by these weights is nearly as great as the horizontal backward and forward force exercised by them in balancing the movement of the reciprocating part. This force, the vertical action of the rotating eccentric weights, sets up vibration in the floor or foundation on which the machinery stands, and, generally speaking, the action of the weights is not confined to a vertical direction, but departs therefrom sufficiently to set up racking stresses in the frame of the machine.

in which vibration is set up by reciprocating parts may be so constructed that the waste referred to may not only be prevented, but may be converted into useful work, employed in the operation of the essential parts of the machine. It will be shown that this may be done in such a way that the parts operated shall experience much less severe stresses than in any of the arrangements commonly used.

The method of working now to be shown includes a new mechanical motion, involving something of the nature of a mechanical paradox; but it secures a perfectly automatic balance in itself and in the thing it



The whole of the work done in this way is lost work, and some idea of how much that loss may be can be shown by the working of the model marked A. Fig. 2. In this model, vertical motion of small range is imparted by a crank and connecting rod, C; the weight of the crank and connecting rod being balanced by an eccentric weight, W, on a disk, B, on the crank shaft. So long as the piece, D, to which motion is communicated is thus operated, the eccentric weight acts as a balance weight; but it will be seen from the indicators on the model, which, for the purposes of explanation, magnify the range of vibration set up, that the effect of the push and pull on the arm, D, of the machine represented by the model is very considerable. In this respect it represents the condition of working of a good many machines—vibration—which is only prevented by excessive strength and excessive weight. Some idea of the effect in the vertical direction of the balance weights, D, used in the machine represented by Fig. 1, may now be conveyed by allowing the corresponding balance weight, W, in the model, Fig. 2, free scope, by placing the crank shaft and its bearings on the part, D, of the machine represented by the model to which reciprocating movement has to be communicated as shown also in Fig. 3. The connecting rod is dispensed with, and the framing of the machine is relieved of the bearings, so that any work in the vertical direction, or force exerted by the balance weight, will now be expended on the part to be moved, and only on that. The balance weight is now unbalanced by that of the connecting rod and its connections, and by rotating the crank shaft it will be seen that the essential part of the machine now receives vertical movement, just as it did before the connecting rod was removed. This is the effect when the speed of rotation is greater than the elastic period of the part D of the machine moved. If, now, the speed of rotation be altered, so that it may coincide with the elastic period of the part, D, to which the shaft is attached, it will be seen that this same little, out-of-balance weight will set up motion of a very large range. Thus may be afforded some idea of the harmful vibrations which may be set up in the floors and walls of buildings containing machinery, in which forces, otherwise unbalanced, are originated. It must be noted that the force which gives rise to the vertical movement in the machine shown by the model is equally active in tending to produce motion in the direction of the length of the reciprocated part, and it is only opposed by the weight and fixity of the frame of the machine. The force is, however, available for setting up motion or vibration in the horizontal direction of that to which the machine is attached.

Very many machines, such as that represented in diagram, Fig. 1, may be made to perform their work by a gyratory instead of a reciprocating motion, and such machines in considerable numbers and of several kinds are used for the sorting and sizing of grain, crushed ores, and in flour mills. A simple form of such a machine was represented by a diagram on the black-board, in which, as before, A represents a sieve; B, a crank shaft; C, a crank disk carrying a crank pin, by which motion is given to the sieve. The disk, C, is heavily weighted on the side opposite the crank pin, so that the disturbing forces, set up by the gyrating sieve, may be, to some extent, balanced and thereby eliminated. The reaction, however, of the force exerted by the crank pin is equally and oppositely experienced by the bearing, B, with the result that the framing of the machine within which the sieve, A, is suspended must be made of great strength, and it is commonly necessary, even with this strength, to prevent the rocking of the frame by connecting it by struts or ties to the building in which it is fixed. Now the whole of the work expended in setting up vibration of the frame of the machine or the building containing it, is not only waste work, but it is a very harmful waste.

It is one of the chief objects of this paper to show that by far the larger proportion of all the machines

operates. Instead of attempting to make an accurate balance, according to methods hitherto adopted, the author proceeds in an exactly contrary direction, and purposely puts that which gives rise to the motion out of balance.

The cause of vibration, which has hitherto been a source of the greatest trouble to mechanical engineers, is thus converted into a useful servant, and in many cases that which has been a harmful mechanical by-product is utilized and made to do the whole of the

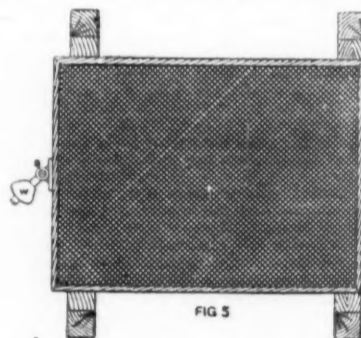


FIG. 5.

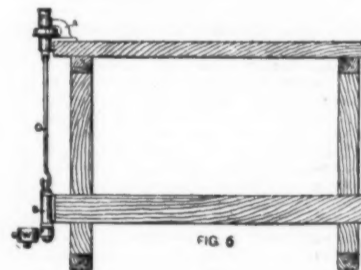


FIG. 6.

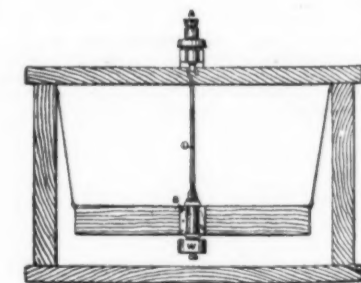


FIG. 7.

work of which it is an offshoot. In brief, the cause of vibration is converted into a vibromotor.

In the model marked B is a part corresponding to that marked A in the diagram, Fig. 1, operated by means of a crank shaft and weighted disk. To the frame is attached an indicator, which makes visible the vibration set up in it, by the wasted reactions. By removing the crank shaft from the framing, and leaving the latter only the work of supporting the sieve, and then operating the sieve by the means which now have to be described, it will be seen that the frame is relieved of those stresses, and, therefore, of the vibra-

* A lecture before the Society of Arts, London, Feb. 7, 1894. From the Journal of the Society.

tory effects, while the work of operating the sieve is materially lessened. To the sieve is attached the bearing for a small spindle which carries an eccentric weight, *W*, Figs. 5, 6, 8, 9, equivalent to that of the weighted part, *C*, of the crank disk, in other words to carry an unbalanced eccentric weight. This small spindle is rotated by a flexible or jointed connection, *C*, which is free to move with the movements of the sieve. Now, as will be seen from the working of the model, *B*, the rotation of this eccentric unbalanced weight sets up movement by its reaction at every part of its rotary path, but it is now running in a bearing, which is attached not to the framing of the machine or any fixed part, but only to that which has to be moved, namely, the sieve, *A*; hence every action and reaction now set up respectively by the rotating eccentric weight and the sieve is expended entirely in the operation of the latter. This being the case, there is now no vibration set up in the framing of the machine, as is shown by the quietude of the indicator, which before was violently agitated. Other models, *C*, *D*, are shown, which further illustrate this, motion being conveyed, in one case, to a reciprocating part by a driving spindle which runs in a bearing attached to a freely suspended frame. Another model, similar to that shown in Figs. 5, 6, 7, 8, 9, is also exhibited in order to show how a gyrating screen may be operated by means which automatically balance all the disturbing forces.

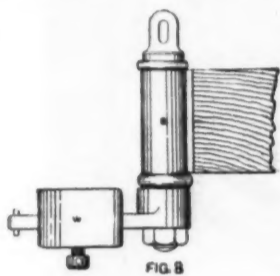


FIG. 8

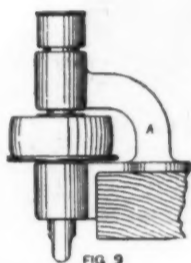


FIG. 9

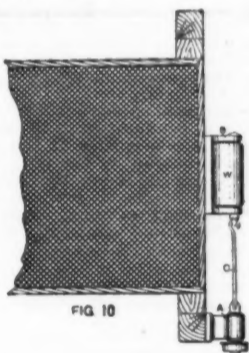


FIG. 10

It is common with most classes of machinery by which buildings are set in vibration to oppose the movement which the disturbing force tends to set up by the inertia of very heavy foundations; but there is the objection to this that the wear of the bearings of the machinery is greater than it would be if it were possible to obtain perfect balance of the moving parts. The system is, moreover, sometimes not successful, even very heavy foundation work failing to prevent the vibration of buildings. The models and diagrams herein referred to show that, in many cases, this may be obtained, and it will have been seen that this is done by permitting the main parts of the machine to move through a range which is precisely in proportion to the disturbing force and the thing which it disturbs. In many cases where the whole of the disturbing force cannot be thus utilized, the absence of perfect balance may be rendered harmless by permitting motion through small range in that which experiences first the effect of that want of balance; and, in general, it may be said that undesired vibration is the result of opposing a force which can either be avoided, by proper balancing of machinery, or prevented by permitting a small range of movement in that machinery instead of endeavoring to hold it absolutely motionless. It is a matter of common knowledge that engine drivers and engineers on many of the old steamboats were in the habit of allowing their holding-down bolts, and sometimes others, to be loose purposely, because by this the shaking of the boat was observed to be less, though the reason given was that the engine ran more smoothly.

In balancing steam engines the difficulties connected with the balance of reciprocating parts by rotating eccentric weights are complicated by the fact that different rotating unsymmetric parts lie in different planes, but it has been shown by Mr. Yarrow, among others, that considerable relief may be obtained by eccentric weights opposite the cranks, after the manner of those shown in Fig. 1, but although the effect of the reciprocation of the piston and connecting rod may be thus eliminated, the eccentric weights set up vibration in a direction transverse to the line of reciprocation. Mr. Yarrow has also gained good results

with small engines, by opposing the vertical motion that would otherwise occur, by the inertia of what he has termed bob weights. These have, however, the disadvantage that they have to be operated by eccentrics which are not frictionless. Such weights, however, might be used, working horizontally in conjunction with the balance weights on the crank, but so operated that their inertia would be opposed to the horizontal movement which is set up by the eccentric weights on the crank shaft. In some cases engines of the marine form, instead of being fixed to a bedplate on the bottom framing, might be suspended near the bottom of the cylinders, by framing which would permit motion through a small range, and when we consider how small that movement need be, it is not improbable that connecting the crankshaft with the screw propeller shaft by couplings such as those used in the French navy, the vibration might be entirely avoided. This may be explained, by reference to diagram (Figs. 11 and 12), which represent a

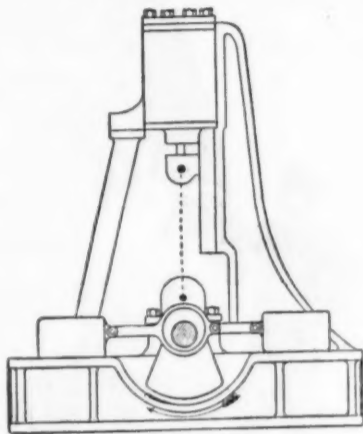


FIG. 11

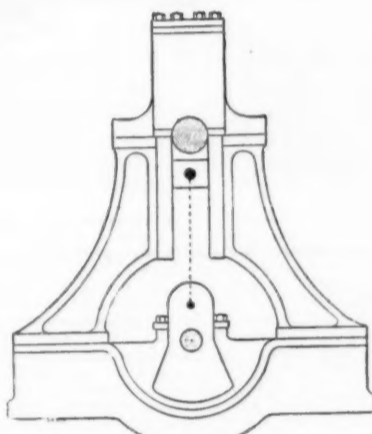


FIG. 12

vertical engine, with the crank, connecting rod, and piston balanced, as against vibrating motion in a vertical direction. The same motion is not, however, balanced, or, rather, prevented, in the horizontal direction, but may, in such cases, be aggravated by the excess of the weight, *D*, over that necessary to balance the crank, the piston, and about half the connecting rod. In many cases, it would introduce practical difficulties in connection with the steam pipes if the engine were allowed to move horizontally, as suggested; but when this is the case, the engine may be fixed, and a weight or weights, *W*, be moved by an eccentric in a horizontal direction. This would neutralize the vibratory tendency; the weights would not be very large, and may be easily predetermined. The diagram, Fig. 12, shows the engine carried by a large trunnion shaft. Assume that the engine represented by Fig. 11 weighs say two tons, and that it is balanced as to vertical forces by the weight, *D*, and that this same weight is say 200 pounds greater than is required for the balance of the forces set up by the parts moving horizontally; then the horizontal movement of the engine, which might be set up by this excess weight, would have a range of half an inch. But if we make the excess weight move something as indicated by the sliding or suspended weights, *W*, shown on Fig. 11, then the vibrating tendency may be practically eliminated by using two weights of 400 pounds, having a stroke of 3 inches. On the other hand, if the engine be suspended as in Fig. 12, and the weight on which the effect of the eccentric weight of 200 pounds can be expended be one ton, then the swing opposite the crank will be one inch.

Model *E* is intended to illustrate the fact that piers of bridges which, during construction, have been loaded with weights considerably greater than those they are intended to carry, have been known to settle afterward, under the influence of vibration caused by passing trains. The model, *E*, represents a small weighted pier, standing in a box of granular material, into which it does not sink, although loaded. Upon setting up vibration of very small range, by means of a vibromotor on a horizontal axis, the pier immediately and rapidly sinks into the material.

As further illustrations of some points in connection with the vibration of buildings, a model is exhibited which shows how vibration, set up by machinery in one part of a building, may give rise to vibration of very different intensity and degree in different floors of that building, and how evidence afforded by two sets of observers may be contradictory and yet both

perfectly true. Model *F* shows a number of superposed blocks intended to represent a small section of a structure such as a wall. When that upon which this stands is caused to vibrate, different parts of this column have very different ranges of movement.

Figs. 13 and 14 and model *G* are illustrative of the usual method of balancing a rotating thing, such as the armature of a dynamo or the drum of a thrashing machine. Fig. 13 may be taken as representing either of these resting on a pair of level knife edges which are commonly used for balancing purposes. When a drum is out of balance it will rest on these knife edges when the heaviest part, or the part most eccentric, is downward. To balance the drum, counterpoise weights are attached somewhere on a diameter opposite this heaviest part until the drum is indifferent and will rest wherever it is placed on the knife edges. This it will do even if the balance is effected by adding balancing weights at either *A* or *A'*, Fig. 13, and for

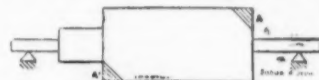


FIG. 13.

a stationary thing this would be sufficient; but it is misleading for high speed machinery. It has been pointed out by Mr. G. Kapp, with reference to apparatus he uses for balancing dynamo armatures, that the added counterpoise must be in the same plane as the excess weight, which throws the armature out of balance, or each weight will act separately in setting up vibration by causing the structure of which it forms a part to endeavor to revolve round the center of gravity of the whole, which is not either at *A* or *A'* coincident with that of the shaft. With a view to the detection of the site of the eccentric weight throwing the whole out of balance, it is necessary to rotate it at a considerable speed, and in such a way that it is free to vibrate as it chooses. This can be done as shown in Fig. 14, wherein the armature, *A*, is placed in bearings,

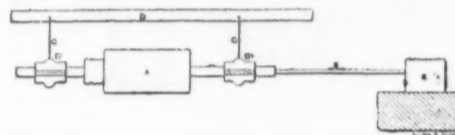


FIG. 14.

*B*¹ and *B*², carried by suspenders, *C* and *C'*, the armature spindle being rotated by a flexible spindle, *S'*, driven by a pulley at *E*. The bearings, *B*¹ and *B*², being free to swing, the amplitude of their movement will, either of them, depend upon the departure of the mass center of the spindle, and it can be seen whether the counterpoise is required at one or both ends.

The same thing may be found by suspending the armature spindle vertically from a vertical rotating spindle by means of a shackle and hooked rod. This is shown by the model, *G*, and the whirling apparatus to which it is attached. The same apparatus affords the means of showing, by means of a spindle and eccentric weight as used in the vibromotor, and shown in Figs. 5 to 9, how various may be the vibrations set up by a spindle rotating an unbalanced mass at different or varying speeds.

The fact that the wall model, *F*, moves is a proof that there is something connected with it that wants to move and we will not let it, or wants to move more than we will let it. Now this is bad policy, and the lesson to be learned from it is that, as we cannot stop the unbalanced thing from moving, we had better make our calculations afresh on the assumption that that fact must not be ignored, and that it must be allowed to move. It is no use trying to stop it, unless we give it something to expend its energy upon. We must let it move because we cannot help it, but we can help letting it move without taking toll. It is one of those "forces in nature which we must direct for the use and convenience of man," and in a general way it may be said that when a piece of mechanism wants to wobble, it is obviously either wrongly constructed, or if it is not and wants to wobble, then let it wobble, but make it wobble something you want wobbled. In most cases it will not wobble so much and never so forcibly if we don't try to stop its wobbling.

APPARATUS FOR PREVENTING ACCIDENTS IN FACTORIES.

SOME time ago Mr. Charles Cambon invented an arrangement that permitted, through an electro-magnet whose armature acted more or less directly upon the cock of the steam port, of employing the power of a motor for immediately stopping it, and that too from any point of the works.

This arrangement, as simple as it was ingenious, had the inconvenience, however, of necessitating the intervention of an electric current, and, consequently, the installation of a dynamo or of batteries to furnish the energy at the moment desired—a complication which is slight, it is true, but which might sometimes suffice to cause a manufacturer to hesitate to pay the cost of the installation.

The inventor, seeing this difficulty, has devised another apparatus based upon the same principle, but in which the freeing of the counterpoise that puts the system in motion is obtained in a still simpler way, and without an electro-magnet, by means of an ordinary air cylinder. This apparatus, represented in Fig. 2, consists of a cylinder, *A*, in which moves a hollow piston, *B*, closed at one end and communicating at the other with a general air conduit, the ramifications of which, ending at different points of the factory, terminate in bulbs, *G*, or leather bellows, fixed to the walls. The base of the piston is provided with a projection, *h*, which is on a level with the underside of a lever, *C*, movable around an axis, *e*, and the short arm of which, beveled at the end, supports one of the arms, *D*, of a bent lever whose other arm is provided with a notch in which rests the hook-shaped extremity of a vertical rod, *E*, carrying the counterpoise. A pressure given one of the bulbs suffices to produce a

compression of the air in the conduit, and, consequently, the ascent of the piston, B, and the freeing of the bent lever.

In lieu of compressed air, rarefied air may be employed by slightly modifying the apparatus so that the starting may be effected through the descent of the piston instead of through its ascent.

In Fig. 2 we show the apparatus as applied to the control of a disengaging gear through the passage of the driving belt from the fast to the loose pulley. The shifting of the ungearing fork, K, is obtained, as in the case of the closing of the steam cock, by a toothed fly-wheel, I, which the descent of the counterpoise, P, causes to gear with a pinion, H, actuated directly by the motor.

In Fig. 1 is represented a certain number of other

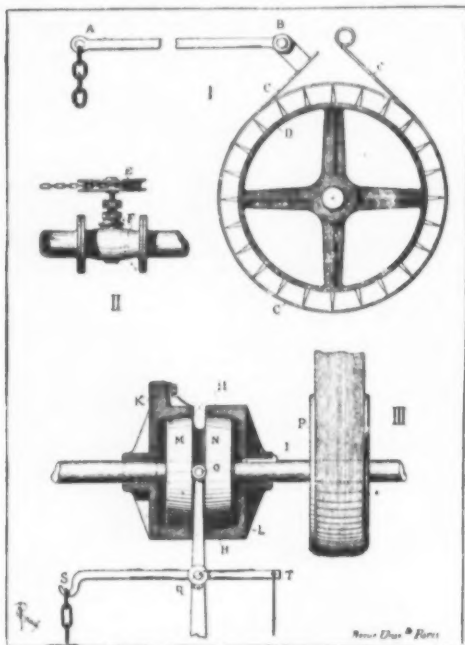


FIG. 1.—VARIOUS APPLICATIONS OF THE APPARATUS FOR PREVENTING ACCIDENTS IN FACTORIES.

applications of the apparatus. Thus, No. I. of the figure shows the system applied to the control of a brake, C, applied to a pulley, D, of wide diameter fixed to the main shaft of the engine or to the shafting that it is desired to effect the immediate stoppage of.

No. II. of the same figure shows the arrangement for the closing of a screw cock placed upon the main steam pipe.

Finally, No. III. shows a new arrangement of brakes devised by the inventor and which permits of effecting a quicker stoppage of the shafting than can be done with the ordinary brake.

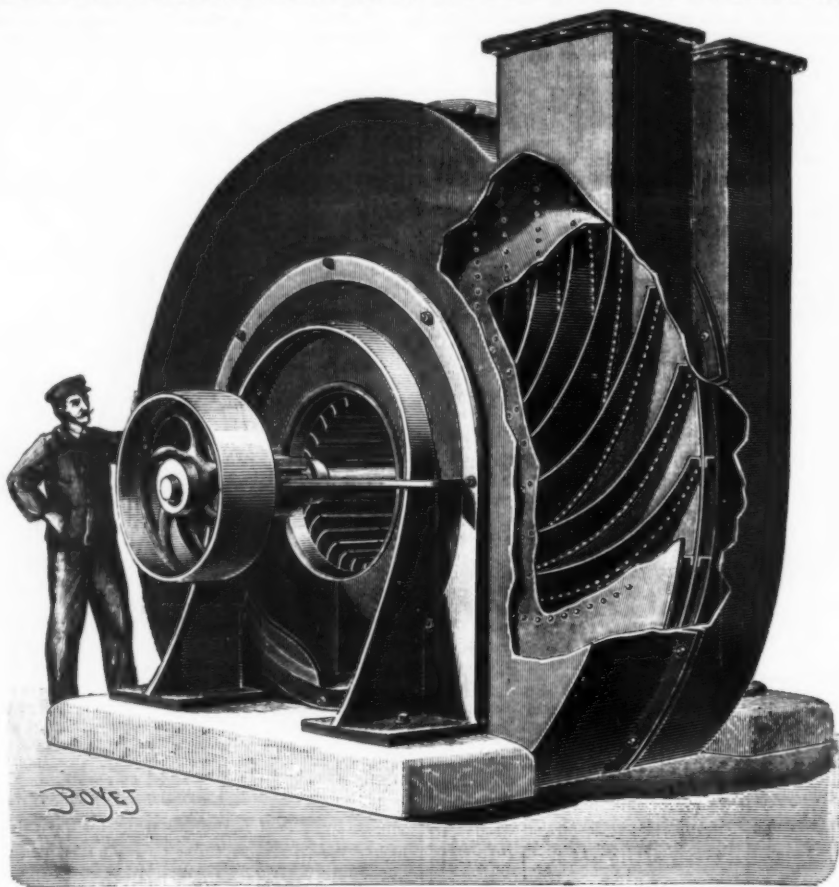
The arrangement consists of a drum formed of two parts, M and N, in the form of truncated cones, united at their wide base and keyed to a transmitting shaft in

two parts, one of which carries the driving pulley, P. These drums are inclosed in hollow cast iron disks, K and L, of the same form internally and provided with a rubber lining, H. The disk L is connected with the driving shaft, while the other, K, is bolted against the wall or a strong framework. In the position represented in the figure, the part of the shaft to the right revolves alone and without transmitting motion to the part to the left. If the starting bar, S T, be acted upon by

by a brake of a power greater than that of ordinary ones.—*Revue Universelle*.

BLOWER FOR SMELTING ON A LARGE SCALE.

In consequence of the substitution of steel for iron, metallurgical works are transforming their old apparatus so as to obtain better and quicker results. In Bel-



BLOWER FOR SMELTING HOUSES.

gium, especially, it is necessary to effect the smelting of iron very quickly. Very high cupolas of from 7 to 8 meters between the dead plate and the throat of the furnace, and of the small diameter of 0.9, 1 or 1.2 meters, are employed in many works.

With well conditioned cupolas, such as these, fusions of from 20 to 30 tons per hour are obtained. The fusion is very rapid, in consequence of the great height and the progressive heating of the layers of metal in measure as they descend upon the dead plate. By reason of such great height, it becomes necessary to employ very strong wind pressures. With a well calculated wind, conduits and tuyeres of a section proportional to the discharge and pressure, there is obtained a true puddling of the metal by the force of the wind, and the percentage of coke consumed is feeble—say about 4 kilogrammes per 100 kilogrammes of molten metal.

This great pressure necessitates special blowers. Mr. Farcot has constructed apparatus of this kind that easily give great volumes with such pressures.

In the apparatus illustrated herewith the turbine is 2.5 meters in diameter and the opening 0.62. The discharge is capable of reaching 6 cubic meters per second and the pressure 0.8 meter at 1 meter of water with a rotary velocity of 700 revolutions per minute. With this apparatus from 25,000 to 30,000 kilogrammes of metal per hour may be smelted. The apparatus runs without noise or vibration. The force of pressure (6 cubic meters) per second to obtain such a result is 100 horses of 75 kilogrammes.

The very high pressure blowers consist of an iron plate turbine, the curve of the buckets of which is a logarithmic spiral of the force $\omega = \log. \text{nat. } \rho \text{ or } \rho = e^{\omega}$, in which the tangent makes a constant angle of 45° with the vector radius.

The bucket is inclined in the direction of the rotary motion. There is thus obtained an increase of centrifugal force for the same number of revolutions, in consequence of the velocity of circumferential impulsion of the molecules of the bucket.

The wind is produced at a pressure increasing exactly with the rotary velocity of the turbine.

The turbine revolves in a cylindrical jacket, and the annular space between it and the latter is so reduced that the pressure is the same in all the buckets and the air escapes laterally through two pipes without producing any vibration.—*Le Génie Civil*.

FLOW OF SOLIDS.

CHANGES of form are very slow—though rapid enough to explain the motion of glaciers—but pressure increases their speed. Tresca, of the French Academy, has proved by his beautiful and varied experiments that under a certain pressure all solids "flow" like liquids, and that their molecules obey in such cases the laws of the motion of liquids.

A block of lead, or of steel, or of ice, placed in a cylinder and pressed upon, is made to flow out of a hole in the cylinder exactly as a jet of water. It remains a solid all the time, but its molecules, whose paths are rendered visible by a special arrangement, are seen to have acquired a certain freedom of motion, and to flow

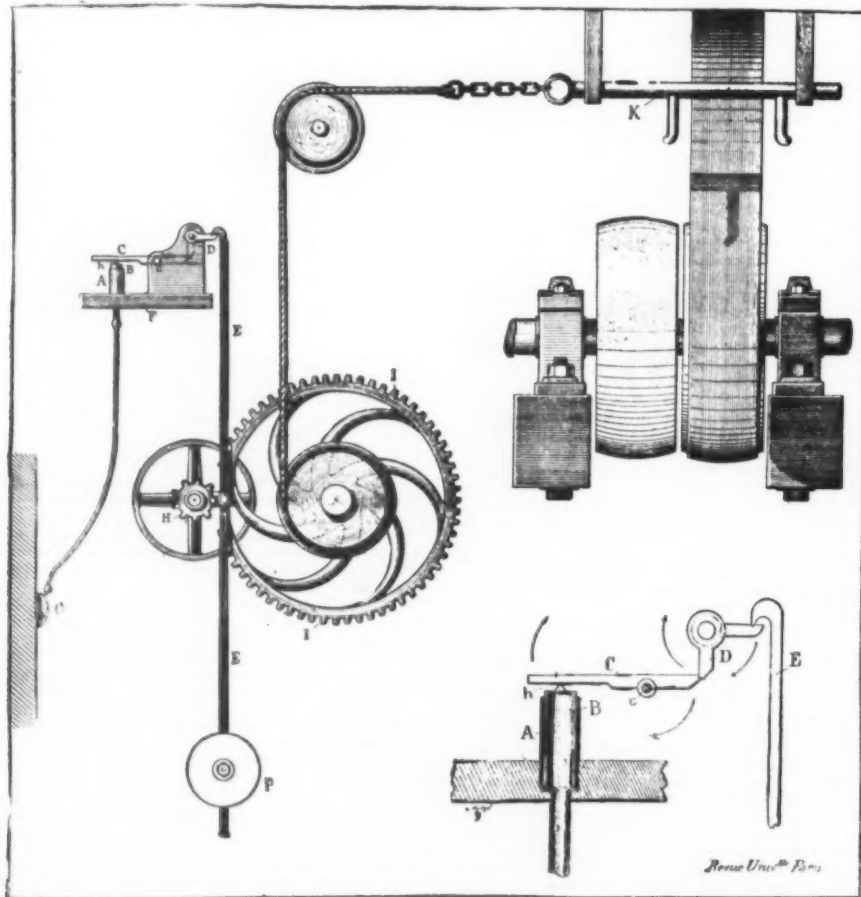


FIG. 2.—APPARATUS FOR PREVENTING ACCIDENTS IN FACTORIES.

in the very same way as molecules of water flow from a hole in a pail.

A cube of lead, steel, stone, or ice placed on a solid surface, submitted to a sufficient pressure or loaded with a sufficient weight, "flows" sideways just as if it were a block of plastic clay. The only difference is that clay flows under its own weight, while steel requires an immense pressure in order to "flow" in its solid state.

As to ice, it stands between the two—much nearer, of course, to the former than to the latter, if both are taken at ordinary temperatures. A thickness of a few hundred feet, or a corresponding load, would be quite sufficient to make it "flow," though remaining solid, even over a quite horizontal floor, and to behave in its spreading over the floor like a lump of plastic mud, provided its temperature is but a few degrees below zero. This is the net result of Tresca's epoch-making experiments on "the flowing of solids" under pressure, and these experiments have been fully confirmed as regards ice by the experiments of Helmholtz, Pfaff, and especially those of the Bologna professor, Blanconi. —*The Nineteenth Century.*

RIDERS OF MANY LANDS.

THAT Colonel Dodge's latest work is of distinct military value would hardly be inferred from its title,* yet that is its *motif*, from the point of view of one reader.

One may be a horse lover and yet not familiar with the horse for war purposes. To him the red-white-and-blue thread woven into this genuine "horse talk" is evidence that, in his trotting around the globe, Colonel Dodge's "heart was true to Polk," and that his patriotism never cooled a moment amid all the temptations of foreign lands.

One of the first things noted is the catholic spirit with which the subject of horsemanship is treated. Next to doctrinal questions there is no broader field for prejudice to disport itself in than in matters pertaining to the horse; his breeding, training and use—especially under the saddle. The author brings to his work practical experience among the various types of horses and riders described—not mere literary cleverness; and therein lies the value of the book as part of a cavalry library. Each chapter is devoted to a minute description and temperate criticism of the method of riding peculiar to one of a score of the principal countries of the world, with much interesting information as to the relative endurance under the saddle of various types of animals used—the horse, the ass, the camel and the bullock.

Among the more valuable chapters, in this respect, is that upon long-distance rides, in which Colonel Dodge, after due mention of some of the best performances of modern cavalymen, truly shows that the professional *raison d'être* for such experiments lies in the condition of man and beast for further work at the end of the ride.

Thus the late Austro-German long-distance race was a conspicuous and inexcusable display of cruelty to animals, without the slightest military advantage; and such also would seem to have been the result of the detail of a well-fed and high-spirited officer and charger to carry Emperor William's dispatch across country in the shortest possible time; the result of this experiment, if it has any value, tends to throw suspicion upon the condition of the German cavalry for an immediate test of endurance such as might be desirable in the event of war.

As a feat like that of the Oriental horse and rider of 950 miles in 45 days, may be mentioned the ride of Lieut. William P. Sanders, Second U. S. Dragoons (afterward Brig.-Gen. U. S. V., killed at Knoxville), who, accompanied by a sergeant, set out at a moment's notice from Fort Crittenden, U. T., March 30, 1861, in pursuit of deserters, who were caught by him in the neighborhood of Los Angeles, Cal., and turned over at the nearest post for trial. Sanders and the sergeant immediately returned to their post, arriving there on May 31, with the same horses, in good condition, having covered a rough and dangerous route of 1,600 miles in 59 days. Sanders' mount—an average American horse—was used as an officer's charger for four years during the civil war, and fell mortally wounded within the Confederate lines at Winchester in 1864.

The book is unique in its combination of what may be termed professional data with popular literature. Sound horse-sense is deftly intermingled with light gossip on men and things from a globe-trotter's standpoint. It is civil as well as military; it discusses sport in a Frank Forrester vein, and treats of arms and accoutrements of military uniform and muffs; with respectful comments upon the fair equestriennes of Egypt and Hawaii and the utility of the divided skirt. The author does not lack audacity, going so far as to find fault with Phidias and to intimate that there are limits to British horsemanship.

If there are deficiencies in this work, they are of a character easily supplied—at least in another edition. The most serious one (and for this the publisher should share the blame) being the want of a table of contents. The illustrations are numerous, artistic and well printed.

A quotation from the closing chapter of this charming volume reads thus:

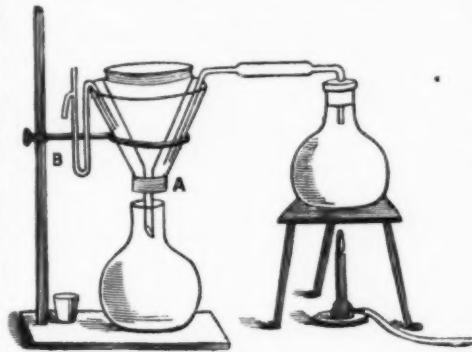
"But after passing in review the 'Riders of Many Lands,' when I again set foot on shore in the United States I could not but feel that this country of ours is the home *par excellence* of horsemanship. This idea is not, I think, bred solely of national pride; my readers will surely absolve me from narrowness or provincialism in the matter of equitation, or from any set scheme to rob other nations of their due. I am happy to admit, for it is manifestly true, that the best sportsman in the saddle is the Briton. On the other hand, the German is as far and away ahead of him in military riding—that is, in the drilling of bodies of horse—as the Frenchman is ahead of him in the niceties of breaking, training and *manège* riding. Where to place the Arab it is hard to say. With all due respect to the man or the race that produced the original strain of blood on which we all rely for our speed and endurance, I do not think that the best Arab is as good a rider as the best European or American; while the average Arab is, in efficiency, far below our riders under parallel conditions. The Cossack makes, no doubt,

the best half-barbaric light cavalry in the world, and in his element is hard to equal. But after all it must be allowed that in some matters equine we Americans are pre-eminent. I will venture to claim that in distance riding, which is perhaps the very highest form of horsemanship, we Americans are quite unapproached. Added to all this, the fact that we have enriched the world with a brand new type in the trotter, and that in racing and in polo and hunting we are fast catching up with our English cousins; and while I do not wish to 'claim everything,' I think—to recur to my original word—that it must be 'allowed' that in all-round ability to breed, train and ride the horse to the very best advantage, the American is *primus inter pares*." So say we all of us.—T. F. R., in the *Jour. of the Military Service Institution.*

HOT WATER FUNNEL.

I HAVE lately constructed a simple form of hot water funnel which, I think, is better in some respects than the ordinary copper-jacketed funnel usually employed for filtering liquids which require to be kept hot during the process. It consists of two glass funnels fitted one inside the other by an India rubber plug, A, on the neck of the inner funnel, around which the outer funnel fits as a collar. The top of the inner funnel projects somewhat in order that the filtering liquid may be conveniently covered. The interspace contains water, which is kept hot by blowing steam into it, and the excess of water thus formed is carried away by a constant level siphon, B; a strip of wet tape hanging over the edge of the outer funnel answers the same purpose.

The chief virtue of this kind of hot water funnel lies in the fact that it can be constructed in a few minutes out of ordinary laboratory apparatus at a very small cost; but it has a second advantage, for by employing steam to maintain the temperature instead of the naked flame generally used with the copper-



jacketed funnels, all risk of inflammable vapors from spirituous and other liquids becoming ignited is avoided.—Charles R. Beck, in *Chemical News.*

ANCIENT EGYPTIAN PIGMENTS.*

THE red pigment used by the Egyptians from the earliest times is a native oxide of iron, a hematite. Most of the large pieces found by Mr. Petrie are an oolitic hematite. One specimen on analysis gave 79.11 per cent. and another 81.34 per cent. of ferric oxide. The pieces to be used as pigments were no doubt carefully selected, and the samples that I have examined, mostly from Gurob and Kahun, are very good in color. All the large pieces were of a singular shape, having one side smooth and curved; and in all cases this side was strongly grooved with striae, giving somewhat the appearance to the mass of its having been melted, and allowed to cool in a circular vessel. No doubt the explanation of this smooth curved surface is, that these pieces had actually been in part used to furnish pigments, and having been rubbed with a little water in a large circular vessel, had been ground to this shape. By experiment it was found that these pieces of the native hematite yielded, without any further addition by way of medium, a paint which could readily be applied with a brush, as it possesses remarkable adhesive properties, and it resembles exactly, in every particular, the red used in the different kinds of Egyptian paintings. In addition to these samples of the pigments, all of which are native minerals and in their natural conditions, there are other reds, finer in color and smoother in texture, evidently a superior pigment; these apparently have been made from carefully selected pieces of hematite, which have been ground and washed, and dried by exposure to the air. Some of these pieces are very fine in color, and it would be difficult to match them with any native oxide of iron that is used as a pigment at the present day. There is every reason to believe that this is the earliest red pigment which was used, and it remains to this day the commonest and most important one; it is a body unattacked by acids, unchangeable by heat, and even moisture and sunlight are unable to alter its color. At the present time many artificial products are used to take the place of this natural pigment.

Yellow Pigments.—These, again, are natural products, and by far the most common yellow used by the Egyptians is a native ochre. These ochres consist of about one-quarter of their weight of oxide of iron, from 7 to 10 per cent. of water, and the rest of their substance is clay. When moist they have a greasy feel, and work smoothly and well with the brush. There is no evidence of these bodies having changed color, but undoubtedly they are chemically not nearly so stable as the red form of oxide of iron. Many of the pieces of this pigment, found at Gurob and at Tel-el-Amarna, are very fine in color.

Some of the specimens of the very earliest colors of which the exact history is known appear to be an artificial mixture of these two colors, the red and yellow, thus producing an orange color. These samples were found on a tomb at Medum, which, according to Prof. Flinders Petrie, was built by Nefermat, a high official and remarkable man at the court of Seneferu.

Seneferu is known to have lived in the fourth dynasty, about 4000 B. C., and to have preceded Khufu, the Cheops of the Greeks, who was the great pyramid builder. Now, on Nefermat's tomb the characters and figures are incised and filled in with colored pastes, which I have been able to examine, and it is of interest to know that this use of color was a special device of Nefermat, for on his tomb is stated that "He made this to his gods in his unspoilable writing." In this unspoilable writing the figures are all carefully undercut, so that the colored pastes, so long as they held together, should not be able to drop out. All the pastes used are dull in color, consisting entirely of natural minerals. Hematite, ochre, malachite, carbon, and plaster of Paris appear to be the materials used. Chessylite, as a blue, probably was known even at that date, but the artificial blues seem hardly at this period to have come into use; certainly they are not found in the specimens of the Nefermat colors which I have examined. Another yellow pigment, far brighter in color, was also often used. It is a sulphide of arsenic, orpiment; it is a bright and powerful yellow, again a body found in nature, but a much rarer body than ochre, and consequently, probably was only used for special purposes, when a brilliant yellow was required. As far as it is known at present, this pigment did not come into use until the eighteenth dynasty. Gold might even be placed among the yellow pigments, for it was largely used, and with wonderfully good effect. Its great tenacity seems to have been fully recognized, for gold is found in very thin sheets, and laid on a yellow ground, exactly as is done at the present day.

These pigments are then simply natural minerals, no doubt carefully selected, and sometimes ground and washed previous to being used; but the blue color which is so largely used by the Egyptians is an artificial pigment, and consequently has far more interest attached to it than those already mentioned. It is a body requiring considerable care and experience to make, and thus its manufacture enables us to some extent to judge of the knowledge and ability which its producers had of carrying on a chemical manufacture. No doubt the splendid blue of the mineral chessylite was first used, but certainly in the twelfth dynasty—that is, about 2500 B. C.—these artificial blues were used. They are all an imperfect glass, a frit, made by heating together silica, lime, alkali and copper ore.* The number of failures which may have occurred, and how much material may have been spoiled, cannot be known, but all blue frit which I have examined—and it is a considerable amount, some being raw material, lumps as they came from the furnace, and the rest ground pigment—all has been, though differing in grain and quality, well and perfectly made. Now this implies that the materials have been carefully selected, prepared, and mixed, and that definite quantities of each were taken, this necessitating the careful measuring or weighing of each constituent—an early application of the fundamental law of chemistry, combination in definite proportion. The amount of copper ore added determined the color; with 2 to 5 per cent. they obtained a light and delicate blue; with 25 to 30 percent. a dark and rather purple blue; with still more the product would be black; if the alkali was too little in amount, a non-coherent sand resulted; if too much, a hard stony mass is formed, quite unsuitable for a pigment. The difficulties, however, did not by any means end with the mixture of the materials. For the next process, the heating, is a delicate operation. Unfortunately up to the present time the exact form of furnace in which this operation was carried on is not known. The furnaces were probably, especially after use, very fragile structures, and have passed away. Considerable experience in imitating these frits even when using modern furnaces has taught me that the operation is really a very delicate one; the heat has to be carefully regulated and continued for a considerable length of time, a time varying with the nature of the frit being prepared; and, further, in the rough furnaces used it must have been specially difficult to have prevented unburnt gases from coming in contact with the material; but if they did, a blackening of the frit must have taken place. However, all these difficulties were avoided, and a frit was made which exactly answered all the necessary requirements. It had, for instance, the right degree of cohesion, for many of the large pieces which have been found have, like the hematite, a smooth, curved striated surface, and on rubbing in a curved vessel with water, easily grind to powder.

The powder is naturally much less adhesive than the hematite powder, but on adding a little medium, it could at once be used, without other preparation, as a paint. Some of the pieces vary in color in different parts. This may have arisen from imperfect mixing, or from some parts of the furnace being hotter than others. It hardly appears to be intentional; possibly some of the dark, purplish colored frits were produced by accident; large pieces of it have as yet, I believe, not been found. By means of comparatively small alterations these frits could be obtained of a green color. One way was by introducing iron. If, for instance, the silica used was a reddish colored sand, it gave a greenish tinge to the frit; and frit made with some of the ordinary yellowish desert sand was found to give a frit undistinguishable from the most common of the old Egyptian frits. Again, a rather strong green color is obtained by stopping the heating process at an early stage, this green frit simply on heating for a longer time becoming blue. Another way in which even the strong colored blue frits have been converted into apparently green pigments is by their being coated over with a transparent but yellowish colored varnish which has to a remarkable extent retained its transparency, but no doubt become with age more yellow, and although strongly green now, may very likely originally have been nearly colorless, and consequently the frit was then seen in its original blue color. Even as early as the twelfth dynasty the green frits used were dull in color, and if by chance a brighter green was required, then they used the mineral malachite.

* A sample of the pale blue frit gave, on analysis, the following results:

Silica	86.65
Soda	0.81
Copper oxide	2.09
Lime	7.88
Iron oxide, alumina, etc.	0.57

* "Riders of Many Lands," by Theodore Ayrault Dodge, Brevet Lieut. Col. U. S. A. Harper Bros., New York. 1894.

* A lecture delivered at the Royal Institution of Great Britain, on March 17, 1893, by Dr. William J. Russell, F.R.S.—*Nature.*

No doubt by far the most brilliant blue used at any time was selected and powdered chesylite, and even down to the twenty-first dynasty they seem to have made use generally of somewhat brilliant colored frits; but after that time more subdued colors appear to have been used, and even the scarabs were made of a much duller color than formerly. All these blue frits form a perfectly unfadeable and unchangeable pigment. Neither the sun nor acids are able to destroy or alter their color.

The only other pigment to which I can refer this evening is the pink color, which in different shades was much used. This is again an artificial pigment, and belongs to an entirely different class from any of the foregoing ones, for it is one of vegetable origin. On simply heating it, fumes are given off and the color is destroyed, but a large white residue remains; this is sulphate of lime. It may here be stated that the white pigments used sometimes were carbonate of lime, but more generally sulphate of lime in form of gypsum, alabaster, etc. This substance is often very white in color, is very slightly soluble in water, and has a singular smoothness of texture, which makes it work well under the brush; and in addition to these qualities, it is a neutral and very stable compound; so is well fitted for the purpose to which it was applied. It was easily obtained, being found native in many parts of Egypt. It is also interesting to note that there is an efflorescence consisting of this substance which frequently occurs in Egypt, and is of a remarkably pure white color; probably this was used as a superior white pigment. It was easy to prove then that the pink color was gypsum stained with organic coloring matter, and to try and imitate the color appeared to be the most likely way of identifying it. Naturally, madder, which it is known has from the earliest times been used as a dye, was the vegetable coloring substance first tried, and it answered perfectly, giving under very simple treatment the exact shade of color to the sulphate of lime which the Egyptian pigment had. Essentially the same coloring matter may have been obtained from another source, viz., Murex. In the case of madder it is interesting to note that the color is not manifest in the plant—the *Rubia tinctorum*—for it is obtained from the root, and is even not ready formed there. In the root it exists as a glucoside, and this has to be decomposed before the color becomes manifest. In this root there exist several coloring matters, which are known as madder red, madder purple, madder orange, and madder yellow. On breaking up the roots and steeping them in water for some length of time, the colors come out, some sooner than others, so the tints vary. Again, changes of color are easily obtained by the addition of very small quantities of iron, lime, alumina, etc., so that in these different ways a considerable range of colors could be obtained, but a delicate pink color was the one probably generally made. This color is easily obtained by simply stirring up sulphate of lime in a tolerably strong solution of madder, and adding a little lime, taking care to keep the coloring matter in excess; the coloring matter adheres firmly to the lime salt, and this settles on to the bottom of the vessel; the liquid is then poured off and the solid matter, if necessary, dried, or mixed, probably with a little gum, and used at once without other preparation. That the coloring matter was really madder could also be tested by another method, viz., by means of spectrum analysis. Both the madder red (alizarin) and the madder purple (purpurin) give, when the light which they transmit is analyzed by the prism, very characteristic absorption bands; the purpurin bands are the ones most easily seen; consequently it became a point of considerable interest to ascertain whether from a specimen of this pigment, some thousands of years old, these absorption bands could be obtained. A small sample of this pink pigment was taken from a cartonnage which was exhibited, and by treating it with a solution of alum, the color was thus transferred to the liquid, and by throwing the absorption spectrum which it gave on the screen, and comparing it with the spectrum from a madder solution, it was clearly seen to be identical.

Many specimens in imitation of different colored frits, and a large copy of a cartonnage colored with pigments prepared by the lecturer, were exhibited.

SPEED OF PROPAGATION OF AN ELECTRICAL DISTURBANCE.

An ingenious method of determining the rate at which an electrical disturbance is propagated along a copper wire was recently described by Mons. R. Blondlot before the Paris Academy of Science. The method is particularly interesting, since it possesses the advantage of being independent, not only of any theory, but even of the existence of electro-magnetic oscillations and undulations.

The apparatus is simple, and the special feature is shown in the accompanying figure. Two condensers, A and A', in every respect similar to each other, are formed each of a cylindrical lamp chimney coated within and without with tin foil. Each of the two external armatures is divided into two annular parts, the one insulated from the other, namely, a and a' in the case of condenser A, and a'' and a''' in condenser A'. The internal armatures are respectively connected up to the terminals of an induction coil, the wires being joined to the curved brass rods shown in the figure, which are in connection at one end with their respective armatures, and at the other end with the ball, b or b' . Between b and b' there is a gap of from 6 to 8 mm. From a and a' branch out toward each other two short horizontal pointed brass wires, p and p' , and separated by a distance of 0.5 mm. To a and a' are respectively connected the copper wires, c and c' , each 1.029 m. long, 3 mm. diameter, and terminating as shown in the figure at the points, p and p' . The dotted lines indicate the positions of damp threads, by means of which the two exterior armatures are connected electrically.

The discharge of the condensers is effected by a spark passing between b and b' . At this moment the charge on the external armatures is set free, and a difference of potential is suddenly set up between a and a' on the one part and between a'' and a''' on the other; the damp threads do not play any part at this moment on account of the extreme rapidity of the phenomena. The armatures, a and a' , are discharged by a spark passing between the points, p and p' ; similarly the armatures, a'' and a''' , which are connected to the same

points by the long wires, a'' , c , p ; a''' , c' , p' are discharged by a spark between p and p' , taking place subsequently to the first, since the disturbance has to travel a distance of 1.029 m. The interval of time between the first and second sparks, between the points, p and p' , is the time taken by the disturbance to travel the distance along the copper wire, and to determine the speed of propagation it suffices to measure the interval, since the distance is known. Mons. Blondlot effected this by concentrating the light from the spark by means of a concave mirror movable around an axis parallel to p , p' , and received on a vertical screen the doubled image of the spark. Given the speed at which the mirror is spun round, its distance from the screen, etc., the rest becomes a matter of simple calculation. A photographic plate may be substituted for the screen.

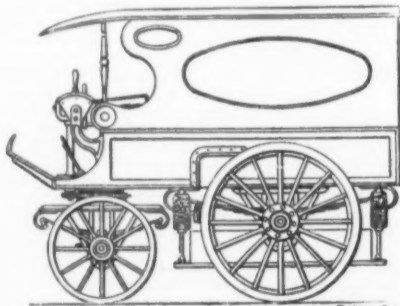
The results of fifteen experiments gave a mean speed of 296.4 kilometers per second. A set of experiments



made on a wire, 1,821.4 m. long, gave a mean value for the speed of 298 kilometers per second. The approximate equality of these values, obtained on lines of different lengths, shows that the movement of propagation is fairly uniform, and the numbers found are in accord with those previously obtained by another method by Mons. Blondlot.

ELECTRICALLY PROPELLED VEHICLES FOR ORDINARY ROADS.

ELECTRICAL vans and omnibuses are now being run on demonstration journeys by Messrs. Clubbe & Company, Elm Street, London. The illustration which we subjoin gives a general side view of the electrical parcel van of the latter firm, on which we have recently had the opportunity of making a trip through some of the most crowded London streets. It resembles an ordinary two-horse van without shafts. The current is supplied by E. P. S. accumulators hung below the body of the vehicle; these with one charge can propel it 50 miles at any desired speed up to ten miles an hour, and when run down can be changed for a fully charged set in a couple of minutes. The steering is said to be very easy and satisfactory, and is managed from a wheel worked by the driver's right hand. The motor oc-



cupies a small part of the interior, which is lighted by two electric lamps. It is stated that this van can be run and maintained at about half the cost of one of the same size drawn by horses.

FISH POISONS.*

By J. B. NAGELVOORT.

FISH poisons are remarkable substances. As far as known, they belong partially to the alkaloids, in part to the glucosides. Many are saponin-like bodies, but our knowledge of a great many of them is nil.

The best known are the berries of different species of cocculus (fishberries in English, Fischkorn in German), which certain classes of people in Europe and Asia regularly employ to catch (poison) fish. But among the more cultivated classes the knowledge of this craft seems to have been lost. The unripe or ripe berries of the cocculus are rubbed to a pulp, and this

pulp is simply thrown into the water, whereupon the fish become semi-intoxicated, rise to the surface and are easily caught.

There is always some risk connected with the use of these berries, and where a government does its duty it is strictly prohibited to sell fishberries; but fish caught with any one of the many other fish poisons are usually harmless as food for man. This is in itself not so remarkable, inasmuch as we often meet cases of the converse—animals partaking with perfect impunity of plants which contain poisons deadly to human beings. Furthermore, the fatal dose for a fish is usually—not always—too small to harm man.

The inhabitants of Ceylon have the dangerous custom of using the very poisonous fruit of *Hydnocarpus venenata*, Gaertn., to poison the rivers. But to eat the fish caught involves great risk to human life.† This is no occasion for wonder, since we learn from Greshoff that he found HC_2N in an oil derived from the plant.

As evidence that the knowledge of catching fish by poisoning them wholesale seems to have been lost among the more civilized portions of society, or is not widespread—proof that half of the people do not know how the other half live—I may cite the fact that the *Encyclopædia Britannica*, in an elaborate article on "Fisheries," does not give any information on our subject.

If the use of certain fish poisons is attended with risk, not so with the bark of *Zanthoxylum scandens*, Bl., a plant found in tropical Asia and Australia. The bark is pounded to a pulp; this is thrown in the water; presently the fishes are seen on the surface dead. They can be eaten, however, with perfect impunity.

The bark of *Walsura piscidia*, Roxb., as the name of the plant indicates, has some connection with fish and fisheries. It is a plant of British India, Malabar, and Ceylon. The bark is thrown into ponds to kill fish, which, coming to the surface, are easily taken and are not considered injurious as food.

From *Serjania lethalis*, St. H. (many *Serjanias* bear a suspicious name—*S. noxia*, *S. inebrians*), the fresh branches are used in Bolivia to poison the rivers; and Weddell (*Voyage en Boliv.*, 1853, 449) states: "I am informed that fish thus caught do not cause any inconvenience when eaten."

The bark of *Paullinia pinnata*, L., a plant growing anywhere in (tropical) Brazil, Mexico, Guiana, the Antilles, and equatorial Africa, is used in Brazil to poison the watercourses, and the fish thus caught are harmless as food.

Tephrosia Vogellii, Hook., furnishes the fish poison *par excellence*. A French African traveler, M. Griffon du Bellay, states: "Nothing so easy as to 'fish' with this plant. I have seen them take a few handfuls of leaves only, throw them in the water, and all the small fish came immediately to the surface, dead. Soon after a kind of lamprey came gasping for air and was easily caught. The fish tasted excellent." (*Adansonia*, vi., 235.) Col. Grant collected the plant in 1862, in the country between the Albert and Victoria Nyanza lakes, and wrote: "A mash is made of this plant by the natives to kill fish. The mash is thrown into the water; the fish float to the surface dead and are taken for food." (*Transact. Linn. Soc.*, xxix., 55.)

Of another *Tephrosia*, found in the South Sea Islands (*T. piscatoria*), different authors tell us that the branches and leaves, thrown into the water, kill the fish without thereby rendering them unfit for consumption by the natives. (De Lanessan, Hillebrand.)

This is one of the most remarkable features of fish poisons: that they act in dilutions containing an amount of the poisonous principle too small to be detected by chemical reagents. It has, therefore, for quite a while been the custom in analytical laboratories to submit fishes to the same experiments as are made on warm-blooded animals, when properties of newly discovered active principles from plants, or what are considered to be active principles, are to be studied. Prof. Plugge (Groningen, the Netherlands) mentions (*Arch. f. Exper. Pathol. u. Pharmacol.*, xxxiii.) that a gold fish of 25 g. died in water containing only 1/10000 of its volume of a new alkaloid that he had under investigation (Pithecolobin).

It is greatly to the credit of Dr. Greshoff (of late, chemist to the Botanical Gardens at Buitenzorg) that he used the unsurpassed facilities at his command in the library of the garden, and brought together in one book (from which the above is extracted) what was previously scattered throughout general literature. This work deserves our praise all the more, as we yet bear fresh in our memory the wealth of suggestions and of original discoveries which he poured out from the treasury of the flora of the Malayan Archipelago in his first report from his laboratory.† Standing as apothecary on the borderland between the professional botanist and the chemist *sui generis*, devoted to science for its own sake, a fluent writer and accomplished scholar, he has given us no monograph of which we may say that no other like it exists.

At the author's request I have the honor and the pleasure of introducing it to an English-speaking public; for, to my regret, it is written in Dutch. But as Greshoff, when I called his attention to this disadvantage, responded that any one once interested in the present subject would find out his work, I have no further ground for objection. Every reader will acknowledge that Greshoff did not serve "tonjours perdré" in his intellectual bill of fare. The author himself invites a statement of the experience of others—to which request I call the attention of the United States Fish Commission.

We must be astonished at the insignificant part analytical chemistry has played in developing our knowledge of the nature of fish poisons. On general principles it is not to our discredit that savages caught fish by intoxicating them, long before we had the least idea of such methods. They had arrow poisons too (curare) of which we knew very little until lately. We *fin de siècle* people live too artificially and are little in touch with nature. But that Greshoff's monograph quotes poisons of which most of us (I for one) never heard is humiliating.

His index shows 233 plants. One other book on the same subject, in the Spanish language, by Ernst, published in Caracas, South America, in 1881, enumerates

* Beschrijving der giftige en bedwelmende planten bij de vischvangst in gebruik, door M. Greshoff. Batavia Landsdrukkerij, 1893. The address is that of the printer. The book is not for sale. A few copies will be offered to colleges of pharmacy in this country.

† Baillon, *Histoire d. Plantes*, vi., 299.

† *Ein Laboratorium f. Pflanzenstoffe*, by Prof. Th. Husemann, *Pharm. Zeit.*, ii., February, 1891, p. 93.

sixty plants only as containing fish poison. Another book, written by Radlkofer, in German (*U. Fischergiftende Pflanzen. Sitz. ber. d. Math. Phys. Classe d. K. Bay. Akad. d. W.*, Bd. xvi., 1886), contains 154 names.

Greshoff has very judiciously furnished such long quotations that we are enabled in many cases to judge for ourselves respecting the merit of the statements. This makes the "Monografia" much more instructive than it would have been if we were referred to the original papers. I think that even a reader unfamiliar with the Dutch language will be largely benefited by a perusal of Greshoff's book, since so many quotations are in French, in German, in English, or in Latin, and we all understand the botanical system he followed (Bentham and Hooker's *Genera Plantarum*) and the abbreviations used.

I do not doubt that my opinion of the utility of the "Monografia" to our growing generation of pharmacists will find opposition. But it seems to me that if they will cultivate, every one according to his own taste and ability, the field here indicated, they can make their influence in science felt, and that it will give them strength to resist the destructive invasion of those purely mercantile interests which would cheerfully wipe out pharmacy, pharmaceutical chemistry, and plant investigation, and make of the possible lover of science a mere automatic salesman.

The experience with fish poisons is not an imaginary one. It rests upon a basis of true physiological experiments.

The "Monografia" gives more than its title calls for.

Of *Zizyphus vulgaris*, Lam., we read: "The leaves when chewed are said to destroy the power of the tongue to appreciate the taste of disagreeable medicines." (*Pharmacographia Ind.*, i., 350.)

Tephrosia toxicaria, Pers., is said to serve as a substitute for digitalis.

Indigofera Anil, L.—A decoction of the indigo root, used as a lotion, effectually destroys vermin.

Erythrina aurantiaca, Ridley.—Three or four seeds, being ground and mixed with food, will kill any dog or cat that eats it. A warm infusion of the inner part of the bark is used in toothache.

Derris elliptica, B.—The roots of this plant, steeped in water, afford a useful insecticide for gardening purposes. The Malaysians use the bark as one of the ingredients in their Iphoh arrow poison.

Piscidia Erythrina, L.—It is stated that the tincture of the bark of the root is intensely narcotic. A decoction of the bark cures the mange in dogs.

Acacia Farnesiana, Willd.—Mad dogs are killed in Brazil by the seeds.

Albizia amara, Boiv.—Its root contains 10 per cent. of saponin.

Begonia Rex, Putz.—The juice is poisonous to leeches, and may therefore be used to kill them when found in the nostrils of animals.

Hydrocotyle vulgaris, L., kills sheep when they eat the plant.

Hydrocotyle umbellata, L., is used in Mexico medicinally (emetic?). A study of the plant is very much to be desired.

Annagallis arvensis, L., kills cattle and horses when they eat the plant.

I close my review with *Verbascum*, L. Chemistry knows nothing of a toxic active principle in any *Verbascum*. *Verbascum* species are used in Spain, Italy, and Greece, not only as a fish poison, but also to destroy mice.

The mulleins (*Verbascum*) approach digitalis, says Lindley (*The Vegetable Kingdom*, 3d edit., 1853, 693). And our highest authority in the history of medicinal plants, Prof. F. A. Fluekiger, does not doubt that the plant to which this property is attributed is indeed a *Verbascum*. Prof. Husemann, in introducing the "Monografia" to German readers, in the *Pharm. Zeitung*, 23, xii., 1893, recalls the fact that *Verbascum Blatteria* is known to have killed sheep.

May Greshoff's "Monografia" kindle a worthy enthusiasm for the advancement of pharmacy in its legal collateral branch, toxicology.—*Bulletin of Pharmacy*.

LOCATING METALLIC BODIES IN THE UPPER AIR PASSAGES.

By E. N. HEARD, M.D., Sandusky, O., Assistant Surgeon, Ohio State Soldiers' Home.

In the *Medical Record*, December 16, 1893, page 798, Dr. J. Mount Bleyer described a method of obtaining a lost intubation tube lodged below the vocal chords. He did this successfully by means of a battery, electric bell, and surgical probe en circuit, the latter consisting essentially of two needles in a handle, across which closure of the circuit was made by the contact of both needles with the lost body at the same time. He con-

sidered the instrument simple, and, indeed, it is both simple and ingenious. But the one I wish to offer is much simpler.

Should there be a telephone in the house, take down the receiver or ear trumpet, together with the attached flexible cord. To one of the free ends of the bifurcation attach the metallic part of your hypodermic instrument, binding it securely by means of cord. To the other free end attach a piece of steel of convenient size to be placed in the mouth (the large blade of a

pocket knife may be made to serve). Place the latter in the mouth and see that it is well in contact with the tongue. Then introduce the hypodermic needle through the tracheal wall, the telephone receiver being held to the ear meanwhile. Should the body be touched, even in the slightest degree, there will be a scratching sound in the telephone. The working of this instrument depends upon the well known fact that two metals of different kinds, when in contact with the fluids of the body, form a sort of battery which will give current sufficient to influence a telephone receiver. A blunt probe may also be used through the air passages, a piece of metal of the same kind being connected with the surface of the body and the telephone. Annexed I give a diagram of the two.

Just here it may be well to say that whatever of plating may be on the syringe, although it does probably make some current with the mouthpiece, yet it makes such a small amount that, being constant in quantity, it makes no practical difference.

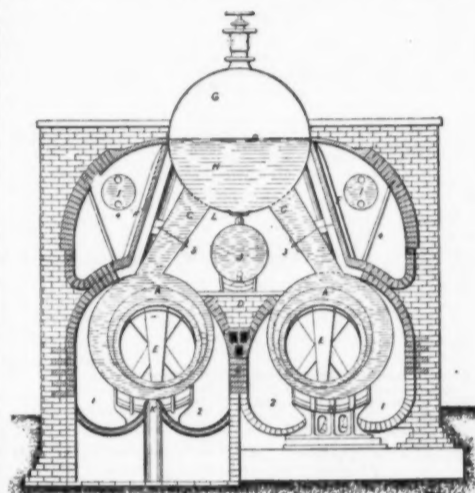
Better contact with the skin (in the second instrument) can be made by making the electrode of a silver dollar and moistening it with salt water or very dilute sulphuric acid.

The advantages of these instruments over that of Dr. Bleyer are three: 1. Little time is needed to arrange the apparatus. 2. The slightest contact will bring response. 3. There is not the least danger of injury.

In the instrument described by Dr. Bleyer, some ingenuity is needed to arrange the two needles, and both of them must be pressed firmly against the metallic object at the same time.—*Medical Record*.

UTILIZATION OF TOWN REFUSE.

A SPECIAL train recently left St. Pancras Station, London, conveying a party of gentlemen who had accepted the invitation of the directors of "The Atlas



Contracting Syndicate, Limited." The object of the visit, says the *Engineer*, was to afford to the party an opportunity of witnessing the installation at Halifax of Livet's patented apparatus for the economical and rapid generation of heat in furnaces and the utilization of dust and refuse for electric lighting. It may be scarcely necessary to remind our readers that, with respect to processes of this description generally, there is nothing novel in the means employed to effect a certain object, or to obtain certain results of the following character: (1) The disposal of solid town refuse, whether wet or dry, by burning. (2) The utilization of the conversion of the products of the combustion of the said refuse into steam. (3) The employment of the steam so generated for electric lighting, as at Southampton and Nottingham, for pumping sewage, as at Batley, and for a variety of useful purposes, both at home and abroad. (4) The manufacture of a kind of cement or mortar out of the residue or by-products of combustion, or the use of them in combination with tar or bitumen for footpaths and flaggings; or again, the clinker can be utilized for the foundation or bottoming of ordinary roads.

The solid refuse of London and other large English cities, among which may probably be included Halifax, contains about 80 per cent. of mixed cinders and ashes, thus providing in a very great degree the materials for its own ignition and combustion. If we now

in a wet condition is the worst. It lies so closely that, without some special contrivance for insuring an efficient circulation of air, the burning of it becomes a matter of extreme difficulty and utterly unproductive of any useful result.

The economy claimed for the process as conducted at Halifax is described as being due to the employment of the Livet steam generator, which is shown in end elevation in the accompanying illustration, and may be thus briefly described. The two heaters are represented by A A, the upper cylinder by B and the conical circulating tubes uniting the upper cylinder to the heaters by C C. A separation, or rather division, is effected by the central wall, D, and the numbers 1, 2, 3 and 4 indicate the different flues in the order in which the gases pass through them after leaving the furnaces and flue tubes of the heaters, E E, on their way to the uptake. It will be seen, on reference to the illustration, that the third and fourth flues of each furnace are separated by fire-tile partitions, supported by the joists, F F. In the upper cylinder, B, the water and steam spaces respectively are shown by the letters H and G. The two upper cylinders of the feed-water heater are I I, while J is the lower cylinder, showing in each the 3 in. internal tubes.

Cast iron stools, K K, carry the two heaters, and L is the interlocking plate which completes the dividing partition between the two third flues of the two furnaces already described. The special feature of this furnace is that the form of the flues is such as will utilize the increasing weight of the products of combustion or gases as they travel toward the chimney, promote a high velocity of the air passing through the furnace bars, produce rapid combustion with intense heat, and cause the gases themselves to pass sufficiently slowly through the flues, so that they part with all their useful heat before they escape into the atmosphere. It is obvious that, in effecting this desirable result, it would not answer to strain or wire-draw the gases too much, or the consequence would be a defeat of the main object. It should be mentioned that the town refuse is delivered at Halifax free of charge at the furnace mouth in a raw state, and shovel-fed into the fire without any preliminary drying, shifting or screening, a very important point in the whole process. There was an entire absence of any unpleasant odor on the premises or in the interior of the furnace or generator house, which may possibly be due to the fact that the constant high temperature maintained, together with the great force of draught, secures complete combustion.

It is stated that the average quantity of rubbish burned per hour per square foot of grate surface of the Livet generator was 33 lb., while the furnaces at Oldham consumed only 25 lb. Both of these results are superior to the average obtained at Glasgow, which was nearly 21 lb.; but it is alleged that a maximum of 39 lb. has been obtained at the last-mentioned town per same units of time and grate surface. If we compare the quantity of water evaporated by the combustion of one pound of town refuse, we find that, while three-quarters of a pound is allotted to Oldham, it is claimed for the Livet generator that in its best performance it has evaporated over four pounds with rubbish containing 20 per cent. of moisture.

The statement for four different towns respecting pounds of water evaporated per pound of rubbish consumed is as follows: Halifax, 4.08; Bradford, 3.65; Harrogate, 3.39; Huddersfield, 3.59. In order to get rid of the objectionable light dust, the progression of the gases is partially arrested at the end of each flue, which enables them to deposit it in suitable expansion chambers or pits, which can be cleaned out as required, so that, after some months' use, the flues themselves have been found in a perfectly free and unclogged condition.

In a small compartment boarded off from the furnace room, but under the same roof of the temporary building of timber and corrugated iron, is simply placed upon barks, without any bolting down, a Parsons' combined steam turbine and dynamo of a somewhat old pattern, which serves to light three arc lamps of 2,000 candle power each, a search light fixed outside on the top of the building of 25,000 candle power and a small incandescent lamp swung over the dynamo. The capacity of installation at Halifax is equal to 100 effective electrical units, or 10,000 incandescent lamps of 10 candle power, each burning six hours a day, by the combustion of 3,000 tons, or one-third of the refuse of the town per annum, which, if the capacity were equal to burning all the rubbish produced, would give one lamp three and a half hours to each inhabitant.

THE MANUFACTURE AND INDUSTRIAL VALUE OF ALUMINUM ALLOYS.*

By J. H. J. DAGGER, F.I.C., F.C.S.

In the two papers I have had the honor of reading before this society, and in a paper read before the British Association in 1889, I gave some account of the present day methods for the production of this industrially new metal, and, expressing my views as to its value, based upon an especial experience of the metal in the laboratory, foundry, and workshop, I then stated that "the greatest value of aluminum is as yet in its alloys;" that these words hold true, and that the alloys of aluminum have a value that can hardly be overestimated, I will endeavor to set forth this evening. Aluminum alloys readily with all the common metals, with one or two exceptions, and with gold, silver, and platinum. These alloys may be conveniently considered as divided into two classes, simple and complex; aluminum alloyed with one metal or with two or more.

The Simple Alloys.—The most important are the copper alloys; these form two series: Aluminum bronzes with 1 to 11 per cent. of aluminum and aluminum copper alloys with 90-99 per cent. of aluminum. The intermediate alloys form a series differing widely in color and other physical characteristics of great scientific interest, but, owing to their crystalline, brittle nature, valueless in the arts. The 10 per cent. aluminum bronze is perhaps the best known; it was first prepared by Dr. Percy, of the Royal School of Mines, in 1853, and as early as 1859 a series of experiments

* Read before the Society of Chemical Industry, Dec. 8, 1890.—From the *Journal*.



take the case of the refuse of a large oriental city in India, it will be found to be absolutely devoid of all coal residue or cinders, and to be mainly composed of stable litter, vegetable matter, cattle droppings and a proportion of kitchen refuse, street sweepings and other general rubbish. At certain seasons of the year the whole mass becomes so exceedingly soft and saturated with moisture as to be practically incombustible in a furnace designed for the burning of Continental town refuse. Of all the ingredients, vegetable matter

TABLE I.
ALUMINIUM BRONZE—AVERAGE TESTS

Aluminum Per Cent.	T.S. in Lbs. per Square Inch.	Elongation Per Cent.
10	60-90,000	4-14
8½	55-65,000	12-28
7½	35-45,000	8-35
6-6½	35-40,000	30-40
5	30,000	40-50
1	20,000	40-55
11	100-100,000	0-3.0

were made with it, a mountain gun being cast of it under the direction of the Committee of Artillery of France, and in 1860 further experiments in this direction were made by the Bavarian military authorities, both the French and Bavarian experts reporting that the cost of aluminum bronze was the only thing then prohibiting its use for guns.

In his report on the Augsburg artillery trials, Colonel Weber states that the aluminum bronze resisted a pressure of 97,012 lb. per square inch, while the tin bronze then used gave only a pressure resistance of 39,601 lb. At that time pure aluminum was 38s., aluminum 10 per cent. bronze 4s. 11d., and tin bronze 1s. 3d. per lb.

Aluminum bronze is prepared by two methods. 1. By direct reduction of aluminum ore, such as corundum or rich bauxite in presence of metallic copper in the electric furnace; this method I have previously described.* Since that time, however, the old longitudinal furnace has been replaced by an upright one; the carbon walls now form the negative electrode, the positive being a bundle of carbon rods, plates, or a single carbon cylinder. The positive electrode is coupled to the cable as before, and is capable of being raised or lowered through an opening in the furnace cover; this cover is of iron and is kept cool by the circulation of cold water within it. At the bottom of the furnace is a tap hole closed by a carbon rod. By this method a rich alloy containing 20 to 30 per cent. of aluminum is obtained, which is checked by analysis and standardized by the addition of copper. The following is a typical analysis of this crude bronze or "furnace product":

Copper.....	71.517 (by difference).
Aluminum.....	20.147
Silicon.....	4.116
Iron.....	4.220

By using prepared alumina almost free from silica and iron, a very pure alloy can be obtained.

2. The better and more general method is by direct mixture of the metals in the crucible. The process is as follows: The copper is first melted, and then the necessary quantity of aluminum added in portions, using a perforated ladle to facilitate mixture. For the first addition of aluminum there will be great evolution of heat, rising to incandescence; this gradually diminishes as the remainder of the aluminum is added, care being taken to prevent overheating of the ladle and tools used during the mixing. The tools and ladle must be perfectly clean, free from scale, and it is best to change the hot rod for a fresh one. Black lead pots must be used, and the greatest care taken to prevent the molten metal coming into contact with sand or siliceous matter, for aluminum readily reduces silicon from its compounds. Fluxes must not be used, but carbon may be placed over the molten metal if thought needful. Much trouble and failure to obtain good results in the foundry has arisen from using clay pots, neglecting these precautions, and using too high a mixing temperature. If a bronze requires to be as free as possible from silicon, crucibles lined with carbon must be used. This bronze is of a bright golden color, its density is 7.60, it gives fine castings, is malleable, but requires frequent annealing if worked in the cold. It works well under the tool and takes a high polish.

The alloy containing 11 per cent. of aluminum is higher in tensile, transverse, and torsional strength; a small round cast bar tested by the Leeds Forge Company, Limited, gave T. S. 57,27 tons, or 128,000 lb. per square inch.

This alloy is exceedingly hard and trying to the tools, and in it we have reached the highest useful limit of aluminum in low per cent. alloys. The alloys containing less than 10 per cent. aluminum are all of very great value. The tensile, transverse, and torsional strengths and resistance to compression decrease as the aluminum is lowered; this is accompanied by a proportional increase of elongation. Their color varies from pale yellow to red gold; they can be readily cast, rolled, and drawn in the cold, and can be worked easily at bright red heat. Sheets, rods, bars, and wire are rolled at a bright heat and finished cold. The effect of working and rolling is shown in some of the tests given below. The fracture of the 10 and 11 per cent. bronzes are crystalline, that of the others fibrous.

You will notice that they far surpass ordinary bronze and gun metals, and compare favorably even with steel.

The destructive effect of heat on gun metal (tin bronze) is one of the most serious objections to the use of that alloy. The aluminum bronzes, on the contrary, show no sign of liquation on melting, and there is no separation of the metals on slow cooling, and so sounder castings can be made from them. They retain their tenacity through a high range of temperature. Professor Unwin obtained the following result with a bar of this bronze:

Specimen.	Heated to ° F.	T.S. in Lbs. per Sq. Inch.	Per Cent. of Elongation
10 per cent. aluminum	550°	86,240	26.3
Bronze, rolled bar.....	600°	81,828	27.5

* This Journal, September, 1893.

Other temperature tests made at Cowles Company's laboratory are given in my paper in the *Journal* for 1889.

Complex Alloys of Aluminum.—Of these the most important contain zinc and copper with varying proportions of aluminum, forming the so-called aluminum bronzes. The composition of these alloys varies from 1 to 6 per cent. of aluminum, combined with 12 to 43 per cent. of zinc, the remaining constituent being copper.

The following tables indicate the composition and mechanical properties of this class of alloy.

The percentage of aluminum in aluminum brass depends upon the amount of zinc present, since the aluminum must decrease in quantity with an increase of zinc, otherwise the alloy will become brittle and unworkable. With 40 per cent. of zinc the aluminum should not exceed 1 per cent., with 30 per cent. of zinc 2 per cent. of aluminum, with 11 per cent. of zinc 6 per cent. of aluminum may be added. This alloy is best made by melting 10 per cent. aluminum bronze with the quantity of copper required, and when the ingots are melted and thoroughly mixed in the crucible, add-

ALUMINIUM BRASS.

Notes.	Composition of Alloy.				T.S. per Square Inch.		Elongation per Cent.	Authority.
	Cu.	Al.	Si.	Zn.	Lbs.	Tons.		
Chill.....	63.0	3.5	0.33	33.3	82,260	36.7	2.33	United States Naval Department.
Castings.....	63.0	3.3	0.33	33.3	70,400	31.4	0.40	
Sand castings.....	65.0	3.5	..	..	67,200 to 76,160	30 to 33	8 to 11	Average tests at Milton Laboratory, Works.
Roller bar.....	63.0	3.3	..	..	84,672	37.8	9.7	
Duplicate of above, rolled hot from 3 square inch pillar to 1½ inch, then when cold to 1 inch square pillar.	63.0	3.5	..	..	87,300	39.0	12.5	Pittsburg Aluminium Company, U.S.A.
	57.0	1.0	..	42.0	82,800	23.5	..	
	70.0	2.0	..	28.0	68,000	30.0	..	Tested at Lloyd's proving house, Netherland, for Cowles Company, Limited.
	67.4	5.8	..	26.8	96,900	43.2	..	
Cast bars cut from propeller blade castings:—								Neuhusen Company's Laboratory tests.
6" x 1".....	..	..	..	..	70,147	34.0	1.5	
12" x 2".....	..	..	..	..	72,912	32.5	1.0	Slight
18" x 3".....	..	..	..	..	68,762	29.7	..	
	66.0	1.0	..	33.0	58,240	25.0	50.0	..
	65.0	2.0	..	33.0	60,440	31.0	30.0	
	64.0	3.0	..	33.0	80,480	39.5	7.0	..

TABLE II.

COMPARISON OF ALUMINIUM BRONZE WITH GUN BRONZE, IRON, AND STEEL.

Metal or Alloy.—Description.	Tensile Strength	Elastic Limit.	Elongation.	Authority.
	Lb. per Sq. In.	Lb. per Sq. In.	Per Cent.	
Steel, average—31 137 specimens of accepted gun steel, oil tempered and annealed, hoops, jackets, and tubes. Same grades of steel, 19 specimens not tempered or annealed.	96,150	51,611	19.93	United States Government tests of ordnance metal.
Cast gun steel, German soft.....	70,784	35,392	..	
Wrought iron forgings:—				Holley ("Ordnance and Armour").
Small bars { Highest.....	73,600	30,000	..	
Mean.....	53,000	18,000	26.0	..
Heavy forgings, average of 700 tests.....	48,160	23,700	..	Sir W. G. Armstrong's Works tests.
Cast iron, average of four specimens of accepted iron	30,000	17,000	0.166	Watertown Arsenal United States Government tests.
Gun bronze, average of 14 tests:—				Watertown Arsenal tests.
Copper 88.0, Si 1.0, Zn 10.0.....	38,996	13,214	33.6	
" 92.0 " 8.0.....	29,008	..	..	Anderson.
" 91.7 " 8.3.....	31,061	..	..	"
" 91.0 " 9.0.....	32,906	..	..	"
" 90.0 " 10.0.....	37,900	..	..	"
" 96.0 " 4.0.....	43,300	8,672	40.0	General Uchatius.
" 88.0 " 10.0, zinc 2.0.....	18,000	10,000	2.5	United States Navy Department tests.
" 82.0 " 10.0 " 2.0.....	24,600	11,000	8.2	
" 82.0 " 10.0 " 2.0.....	23,780	13,000	3.7	Tests at gun factory of the Forges et Chantiers de la Méditerranée.
Gun steel, average results of tests of Firminy, St. Etienne steel for French artillery.	96,134	57,796	16.0	
Aluminum bronze:—				United States ordnance tests.
Al 10.0, Si 1.0, Cu 89.0.....	114,514	..	0.45	
" " ".....	109,823	79,894	0.05	..
" " ".....	105,000	..	6.0	..
Report reads probable elastic limit 84,000				..
Aluminum bronze, Al 10, Si 1, Cu 89, rolled hot from 2 inch billet to 1½ inch round bar.	111,460	..	6.5	United States Government Watertown Arsenal test.
Aluminum bronze, Al 10, Si 1, Cu 89.....	128,400	..	Nil.	
" " ".....	90,680	..	5.7	C.S. Company's Works, Milton.
" " 10 per cent. Al.....	80,743	39,737	33.26	Professor Umoim.
" " cast in sand.....	67,310	..	17.0	Watertown Arsenal test.
Aluminum bronze, 7½ per cent. Al, Si 0.75 per cent., Cu 91.75 per cent.	60,800	21,500	32.8	Otis Iron Works test.
Cast in chill mould.....	68,000	24,000	18.2	
Aluminum bronze, Al 7.5 per cent., Si 0.75, Cu 91.75	60-65,000	..	30.0	Otis Iron and Steel Works, Cleveland, Ohio, U.S.
Same after rolling into rod.....	83,000	..	30.0	
Aluminum bronze, Al 7.75 per cent., Si 0.75 per cent., Cu 91.5 per cent.	60,700	18,000	23.28	United States Government, Navy Department tests.
Aluminum bronze, Al 7.75 per cent., Si 0.75 per cent., Cu 91.5.....	67,000	24,000	13.0	
Aluminum bronze, Al 7.5 per cent., Si 0.5 per cent., Cu 92.0.....	46,550	17,000	7.8	Tested at Phoenix Works, Ruhrort, Germany.
Aluminum bronze bar, Al 5 per cent., rolled.....	82,880	..	60.0	
" " 10 per cent.....	91,392	..	1.5	Tests made at South Boston Iron-works by Mr. E. D. Self, on six-inch long bars.
" " 10 ".....	92,512	60,808	2.5	
" " 10 ".....	96,380	83,189	1.0	Watertown Arsenal.
" " 9 ".....	77,066	51,744	9.0	
" " 9 ".....	71,688	43,104	9.0	..
" " 9 ".....	71,680	..	8.5	
" " 8 ".....	67,798	..	12.5	E. D. Self, at South Boston Iron-works.
" " 8½ ".....	71,904	..	28.5	
" " 7½ ".....	69,700	45,472	6.0	..

ing the zinc. The metal is left in the furnace until small test bars taken from it and broken show the required tensile strength and ductility; it is then ready for pouring.

Other alloys of this class contain small percentages of manganese and tin, usually not exceeding 0.5 of either metal.

The following is an example of this alloy:—

Specimen.	Composition.	Tensile Strength.	Elongation.
Cast bar of aluminum-manganese-bronze.	Aluminum .. 2.000	85,000 lb. per sq. in.	24.25 per cent.
	Zinc 34.000		
	Manganese ... 0.300		
	Tin 0.500		
	Copper 63.900		
	100.000		

Metal for rolling into sheets and rods has often 0.5 per cent. of lead added to the alloy. Aluminum brass can be forged and worked readily under the hammer; the working heat must be lowered with the decrease in the percentage of aluminum. The 3 per cent. aluminum alloy with 33 per cent. of zinc can be worked at a dark red heat, contrasting in this respect with common brass. These alloys all give sharp, clean, tough castings, and from their high tensile and transverse strength and their corrosion resistance they ought to be most valuable to the marine and mechanical engineer. They have already been tried as a material for propeller blades, and, judging from results obtained, ought to displace other bronzes in this class of work.

The Casting of Aluminum Bronze and Brass.—The following are the melting points of aluminum bronze, as compared with the pure metal and other alloys and metals:

Metal or Alloy.	Melting Point.
Aluminum.....	1,200
Copper.....	1,900
Iron.....	2,700
Steel.....	4,000
Steel bronze (gun bronze).....	1,100–1,200
Aluminum bronze (aluminum, brass).....	1,900–1,700

In making castings from aluminum bronze and brass the difficulties, as in other metals and alloys, arise from oxidation, contraction, shrinkage, and the inclosing of air bubbles, but no gases are produced during the melting of the alloy, and there is no trouble from the occlusion of gases, as in the case of other metals.

The liquid bronze on exposure to air is instantly covered with a thin film of oxide, which protects the under metal from any further oxidation; in pouring, care must be taken to prevent any of this film getting into the casting; this is best done by making a "pouring gate" or receiver, into which the metal is first poured.

The molten bronze is kept back until the impurities have risen to the surface, when the plug is withdrawn and the clean metal enters the mould. Instead of a "pouring gate" a secondary pot or ladle can be used.

Contraction must be guarded against by having cores of a yielding character, avoiding as far as possible core rods or irons; coarse sand mixed with resin, which softens on heating, makes a good core. To diminish shrinkage the gates must be made as large as possible and the pouring done quickly, and at no higher temperature than is necessary to insure a good casting.

HIGH PER CENT. ALLOYS.

Composition.		Specific Gravity.	T.S. in Tons per Sq. Inch.	T.S. in Lbs. per Sq. Inch.
Al.	Cu.			
98	2	2.71	19.6	43,904
96	4	2.77	19.90	44,576
94	6	2.82	24.70	55,328
92	8	2.88	22.70	50,848
Aluminum	..	2.67	12.0	26,880
Al, 97-98	Titanium, 2-3	..	17.8	40,000
Langley's patent.	..	..	20.7	60,000

High Per Cent. Aluminum Alloys.—Very many experiments have been made to increase the tensile strength and hardness of aluminum, and with considerable success, though at some slight sacrifice of lightness and corrosion resistance. For ordinary foundry and workshop castings the addition of 1-6 per cent. of copper is the most ready and serviceable method. The mechanical tests of such an alloy are shown in the table. The addition of only 2 per cent. of copper increases the tensile strength of rolled aluminum from 12 to 19½ tons per square inch, while 6 per cent. doubles it; a further addition of copper increases both the hardness and brittleness, but the alloys containing between 12 and 90 per cent. of aluminum are industrially valuable.

The Alloys with Tin.—From my own experiments I find the addition of not more than 2½ per cent. of tin to aluminum gives a hard serviceable alloy with a slightly improved color. Richer alloys are crystalline and brittle. (Samples containing 2 per cent. and 50 per cent. of tin were exhibited.)

COMPARATIVE TESTS OF TRANSVERSE STRENGTH.

Material.	Cross Section of Bar in Inches.	Length of Bar between Supports.	Breaking Load.	Limit of Elasticity.	Permanent Deflection.	Resilience.		Percentage Composition.
						At Elastic Limit.	At Ultimate Strength.	
Cast iron.....	1	12	16 to 20	..	..	..	..	..
Gun metal.....	1	12	26	18	3½	0.07	0.12	..
Manganese bronze.....	1	12	54	38	3½	0.15	0.23	..
Aluminum-Hercules bronze ..	1	12	56	50	3½	0.18	0.24	Al 1-1 per cent. Zn 40-42.
Aluminum-manganese bronze.	1	12	61	56	1.8	0.22	0.25	Al 2½, Mn 1, Zn 44, Sn 1.
Aluminum brass.....	1	12	72	64	1	0.2	0.23	Al 3½, Zn 33

CORROSION RESISTANCE OF ALUMINUM ALLOYS. NEUHAUSEN LABORATORY TESTS.

Specimen.	Weight in Grms.	Surface.	Reagent.	Temperature.	Time of Exposure.	Loss Per Cent.
2.4 per cent. aluminum bronze.....	9.346	50 cm. sq.	5 per cent. acetic acid.	Ordinary.	501 hours.	0.440
10 per cent., free from silicon .....	..	Equal surface.	4 per cent. acetic acid and 3 per cent. solution of common salt.	80°-90° C.	15 "	1.0
10 per cent. aluminum bronze with 2.8 per cent. of silicon.*	..	Equal surface.	4 per cent. acetic acid and 3 per cent. solution of common salt.	80°-90° C.	15 "	2.1
Aluminum brass, 3.3 per cent. aluminum.	17.422	22 cm. sq.	Pure conc. H ₂ SO ₄ .	6°-11° C.	336 hours.	4.3

* A specimen tested in the Milton Laboratory indicates the influence of silicon on corrosion resistance. A polished bar of 10 per cent. bronze, normal colour, strength, and elongation, gave following result:—

The action of the sulphuric acid developed a dark band in form of a spiral round the bar; this showed minute corrosion pits under lens, which gave off sulphuretted hydrogen; the corrosion was apparently confined altogether to this dark patch. Silicon alloyed with iron is often left as a black insoluble powder on dissolving the bronze in aqua regia.

COMPARATIVE TRANSVERSE TESTS, ON BARS 1 IN. × 1 IN. × 12 IN.

Gun Metal.				Manganese Bronze.				Aluminum Brass.			
Stress Applied.	Deflection under Stress.	Permanent Set.	Resilience.	Stress Applied.	Deflection under Stress.	Permanent Set.	Resilience.	Stress Applied.	Deflection under Stress.	Permanent Set.	Resilience.
Cwts. 8	0.03	..	..	Cwts. 8	..	..	..	Cwts. 8	..	..	..
10	0.045	..	..	10	..	..	..	10	0.02	0	..
12	0.06	0.015	0.045	12	..	..	..	12	..	..	..
14	0.08	0.04	0.08	14	0.08	..	..	14	0.04	0	..
15	..	..	..	15	..	..	..	15	..	..	..
16	0.15	0.09	0.06	16	0.07	..	..	16	0.06	0	..
18	0.27	0.20	0.07	18	0.08	0.005	0.075	18	0.08	0	..
20	0.46	0.35	0.08	20	0.09	0.01	0.08	20	0.08	0	..
22	0.72	0.65	0.10	22	..	..	..	22	0.08	0	..
24	1.08	0.97	0.11	24	..	..	..	24	0.10	0	..
25	..	..	..	25	..	..	..	25	0.12	0.01	0.11
26	1.20	1.40	0.13	26	..	..	..	26	0.12	0.01	0.11
Slipped through supports.				28	0.20	0.075	0.125	28	0.12	0.01	0.11
Permanent deflection, 3½ in.				30	0.23	0.105	0.125	30	0.15	0.02	0.13
				32	0.28	0.146	0.160	32	0.18	0.03	0.15
				34	..	..	..	34	0.20	0.04	0.16
				36	0.34	0.19	0.15	36	0.22	0.05	0.17
				38	0.41	0.26	0.15	38	0.24	0.06	0.18
				40	0.46	0.33	0.16	40	0.26	0.07	0.19
				42	0.50	0.425	0.165	42	0.28	0.08	0.20
				44	0.70	0.53	0.17	44	0.30	0.09	0.21
				45	..	..	..	45	0.32	0.10	0.22
				46	0.81	0.63	0.18	46	0.34	0.11	0.23
				48	1.16	0.96	0.20	48	0.36	0.12	0.24
				50	1.30	1.17	0.22	50	0.38	0.13	0.25
				52	1.70	1.47	0.23	52	0.40	0.14	0.26
				54	Fractured.			54	0.42	0.15	0.27
					Permanent deflection, 3½ in.			56	0.44	0.16	0.28
								58	0.46	0.17	0.29
								60	0.48	0.18	0.30
								62	0.50	0.19	0.31
								64	0.52	0.20	0.32
								66	0.54	0.21	0.33
								68	0.56	0.22	0.34
								70	0.58	0.23	0.35
								72	0.60	0.24	0.36
								74	0.62	0.25	0.37
								76	0.64	0.26	0.38
								78	0.66	0.27	0.39
								80	0.68	0.28	0.40
								82	0.70	0.29	0.41
								84	0.72	0.30	0.42
								86	0.74	0.31	0.43
								88	0.76	0.32	0.44
								90	0.78	0.33	0.45
								92	0.80	0.34	0.46
								94	0.82	0.35	0.47
								96	0.84	0.36	0.48
								98	0.86	0.37	0.49
								100	0.88	0.38	0.50

The Alloys with Titanium.—For information as to these alloys I am indebted to Dr. J. W. Richards, Professor of Metallurgy at Lehigh University, U. S. A.

The alloy containing 2 to 3 per cent. (Langley's patent) gives a tensile strength of 40,000 to 60,000 lb. per square inch in forgings; this alloy is especially useful for horse shoes, stirrups, bits and small strong fittings.

Alloys with Nickel and Zinc.—The addition of nickel lowers the melting point, and increases the hardness and elasticity, if added in quantities not exceeding 2 per cent. Above this figure the alloy is brittle and useless.

With zinc, aluminum forms hard, close-grained, brittle alloys having a lower melting point than that of the constituent metals. A small ingot containing 10 per cent. of aluminum and 90 per cent. of zinc is among the samples on the table. A very useful alloy contains

3 per cent. of German silver. It has double the tensile strength of aluminum itself. Professor Richards had samples of it tested at Watertown Arsenal, and while not quite equal to the titanium alloy in tensile strength its elasticity was greater; this alloy is suitable for knives, spatulas, paper cutters, spectacle frames, and all uses where elasticity is essential.

Alloys with Silver.—Aluminum alloys readily with silver in all proportions. With up to 6 per cent. of silver the elasticity and hardness increase, beyond this proportion the brittleness increases, but alloys containing up to 30 per cent. of silver are serviceable. These alloys, owing to their hardness, lightness, bright luster and permanency, are excellent for art work.

Chromium Alloys.—For a description of these alloys I have to thank Mr. H. N. Yates. He finds from experiment that the addition of chromium increases the

hardness, while it reduces the strength and ductility of the aluminum.

Cadmium Alloys.—Aluminum is said to form malleable fusible alloys with cadmium in all proportions, but I have not been able to verify this statement.

Alloys with Iron, etc.—Aluminum alloys readily with iron in all proportions. Aluminum containing more than 1 to 3 per cent. of iron is hard and brittle; with 8 per cent. the alloy crystallizes in needles.

Iron containing 15 to 16 per cent. of aluminum cast in the chill is marked by the file with difficulty; the fracture is fine and crystalline.

An alloy of steel containing 1 per cent. of manganese with 7 per cent. of aluminum will just scratch glass. Although aluminum is said by some writers to diminish hardness in iron, used in even small proportions, it is to my mind sufficiently clear that this depends entirely upon the change in the state of the contained carbon.

Above 5 per cent. of aluminum rapidly destroys the magnetic properties of iron, and some time ago experiments were carried out in the Milton laboratory to determine whether this phenomenon would furnish any clue to the percentage of aluminum present in iron alloys, but the results were not precise enough for quantitative indications.

The Use of Aluminum in Melting and Casting other Metals.—Very large quantities of the aluminum produced go for use in iron and steel founding in this country, and Professor Richards and Mr. Yates report that there is hardly a steel melter in the States that tries to do without it, and that they are the largest users. This brings me to the consideration of the influence of minute quantities of aluminum on other metals. The percentage used is so small that such mixtures cannot be truly termed alloys. The action of aluminum is probably twofold, chemical and physical. Chemical, owing to its affinity for oxygen and the stable character of the oxide when formed; physical, causing changes in the structure of the alloy, crystalline to non-crystalline.

The effect of aluminum is due to—

First. Its action on the combined carbon, changing it to the graphitoid form; the carbon is apparently liberated at the moment of solidifying and uniformly. 0.25 per cent. of aluminum added to white iron renders it perceptibly darker in color, 0.5 per cent. darker still, and 0.75 per cent. renders it gray, with no sign of white. Up to 4 per cent. the effect is similar; the castings are softer and grayer as the aluminum increases.

Secondly. Its action on the dissolved oxides of iron and silicon. These are reduced, with the formation of alumina, iron, and free silicon.

Thirdly. Decomposition of gaseous and solid compounds of carbon with oxygen and hydrogen entangled in the molten metal. This is why aluminum is so valuable in steel casting. Some experiments carried out by Professor Langley, of Pittsburg, explain this action clearly. Blow holes in steel are due to non-oxidizing occluded gases, hydrogen, carbonic oxide, and nitrogen separating, under a pressure of many atmospheres, from steel just before solidification. It has been proved by repeated experiment that aluminum readily decomposes carbonic oxide below steel melting heat, forming alumina and free carbon. Professor Langley confirmed this by blowing 40 gallons of pure carbonic oxide through a crucible of molten steel containing aluminum, and obtained an increase of 35 per cent. on the carbon present before passing the gas. The quantities of aluminum used vary with the quality of the steel. For open hearth metal with less than 0.5 per cent. of carbon, 5 to 10 oz. per ton. For steel over 0.5 per cent. of carbon, aluminum must be used cautiously, the quantity usually being 4 to 8 oz. per ton.

These quantities, you will notice, are very minute; 4 oz. per ton being 0.0125 per cent., 16 oz. would be 0.05 per cent. Professor Richards and Mr. A. E. Hunt have patented an alloy made by adding 10 to 30 per cent. of aluminum to ferro-manganese. The addition of the aluminum causes a separation of carbon, and an alloy with less carbon than ordinary ferro-manganese is obtained, admitting of melting softer steel with down to 0.05 per cent. of carbon. As might be expected from its influence on iron and steel, aluminum is useful in the preparation of other metals. It is much used by American galvanizers and brass foundries for adding to molten zinc; its action is to reduce the oxide disseminated through the bath. Its effect on the galvanized sheets is at once perceptible. The amount used is 0.005 to 0.010 per cent. of aluminum, usually in the form of the 4 per cent. aluminum alloy of zinc; one firm in the United States puts 2,000 tons of aluminum zinc on the market yearly. The process is patented in this country. A small quantity added to copper, 0.05 to 0.5 per cent. decomposes entangled oxides and enables sounder and more ductile castings and ingots to be produced without hardening the metal or affecting its electrical conductivity.

In conclusion I would say that the true value of aluminum is not yet known as it ought to be to those engaged in the metallurgical industries of this country, and in its use and applications we are behind the Continent and the United States. In the arsenals, ship-building yards, machine shops, and factories of France, Germany, Switzerland, Italy, Denmark, Russia, and the United States, aluminum and its alloys are taking the place of the older tin, zinc, and copper alloys, of cast iron, and in some cases that of steel itself.

I have to express my thanks to Professor Richards and Mr. H. N. Yates for communication of facts as to experiments and use of the metal in the United States; to the Cowles Syndicate Co. for specimens of alloys; to Messrs. Blackwell for specimens of bauxite; to Mr. Lloyd Barnes, of the Liverpool School of Science, for a test of the electrical conductivity of aluminum; to Dr. Bailey for assistance in preparation of the diagrams; and to Mr. C. Boundy for the use of his metallurgical laboratory.

THIOCARBAMID.

SUCH is the name of a new preparation for clearing and removing stains from negatives. It is very often noticed that the gelatine layers of negatives and positives assume discolorations through the use of certain developers, or when old fixing solutions are used. This discoloration makes such negatives or positives undesirable. For bromide enlargements, for in-

stance, which are still, to a great extent, developed with ferrous oxalate, it is necessary to use a special clearing bath to prevent the yellow staining which would invariably take place. To remove these and other stains, this new preparation in acid solution is specially suitable, and has the advantage (while leaving the image absolutely untouched) of bringing about a permanent removal of stains or discolorations, which cannot be said of other mediums. Its application is as follows: The negative or paper print (bromide or chloride silver plates and papers) are previously fixed with hypo, and after the hypo has been thoroughly removed by washing, the negative or paper print is put into the following solution until the discoloration or stain has disappeared:

Thiocarbamid..... 300 grains
Citric acid..... 150 grains
Water..... 1 quart

Another solution may be prepared by mixing:

Thiocarbamid..... 300 grains
Alum..... 300 grains
Acetic acid..... 150 grains
Water..... 1 quart

The formula of this preparation is as follows:



The solution can also be used for fixing silver chloride negatives and positives. It should be noted that an alkaline solution is inadmissible.

[Continued from SUPPLEMENT, No. 952, page 15230.]

CHEMICAL PROPERTIES OF GASES.*

By FRANCIS C. PHILLIPS.

(III) ORIGIN OF NATURAL GAS AND PETROLEUM.

SOON after the early discoveries of oil and gas in Pennsylvania, the geologists proposed a hypothesis to account for the origin of these remarkable substances.

Remains of the marine vegetation of the Devonian inland sea, as they were gradually buried under the later accumulations of sediment and exposed to gentle heat from below, underwent a slow process of destructive distillation. In this way, all the varieties of petroleum and natural gas were produced. This view, adopted from a purely geological standpoint, seemed so plausible that for a long period no other was thought of. Mr. J. F. Carr, of the Second Geological Survey of Pennsylvania, has discussed the hypothesis very exhaustively in his various official reports. If this view is correct, oil and gas are probably stored products, and are not being continuously generated at the present time.

Opposed to this view is the more strictly chemical hypothesis of Mendeleeff, who, in 1876, expressed his belief that petroleum and gas are of igneous origin.

On account of the high value assigned by astronomers for the mean density of the earth as compared with that of the surface rocks, it follows that the heavy metals are mainly accumulated at great depths where a temperature of fusion may be assumed. Many of these metals combine readily with carbon to form carbides. Iron in form of a carbide, when exposed to steam at high temperatures, is rapidly oxidized, the hydrogen of the water then combining with the carbon set free and producing hydrocarbons.

Citing experiments of Cloez, who produced mixtures of hydrocarbon oils by the action of hydrochloric acid upon ferromanganese, Mendeleeff concluded that such reactions have occurred at great depths below the earth's surface by the contact of steam with incandescent metallic carbides.

"During the upheaval of mountain ranges, crevices would be formed at the peaks with openings upward, and at the foot of the mountains with openings downward. Thus there was opportunity for the water to penetrate to great depths and for the hydrocarbons to escape. The situation of naphtha at the foot of mountain chains is the chief argument in my hypothesis." (Mendeleeff, "Principles of Chemistry," vol. I, p. 365.)

According to this view, oil and gas are being continuously generated, for there is no reason to suppose that the masses of metallic carbides in the earth's interior are exhausted; such, in fact, seems to be Mendeleeff's view.

Mendeleeff points especially to the absence of large quantities of nitrogen compounds in petroleum as an argument in favor of the hypothesis.

The objection has been urged against this hypothesis that petroleum, if thus produced, should be abundant in the primary rocks, from which it is usually absent. The originally heated condition of these rocks would have prevented the condensation of oil, however, and, although the vapors may have passed through the earlier rocks, there is no reason to expect that condensation should have occurred before reaching much higher strata.

While on geological grounds difficult to prove or disprove, it meets with one fatal objection. The composition of natural gas in Pennsylvania does not justify the supposition that superheated steam and carbon have been concerned in its formation. We should certainly look, in such a case, to find natural gas composed mainly of free hydrogen containing small quantities of paraffins, olefines and carbon monoxide. When it is considered that paraffins alone cannot under any known circumstances be produced from the oxidation of carbide of iron by steam, the hypothesis does not seem to be tenable.

It is true that varying conditions of temperature might have produced a great variety of hydrocarbons, but no evidence has yet been obtained that paraffins alone result from such a reaction. In an experiment made with ferromanganese and dilute sulphuric acid, the gas evolved was found to contain 6 per cent. of olefines.† It is further to be noticed that this hypothesis requires that water should take part in the process, yielding up its hydrogen, while, according to the older geological hypothesis, the water may have served mainly to cover and give protection from atmospheric oxidation, if it has been concerned at all in the reaction.

Water contains dissolved oxygen, and in descending

* Read before the American Philosophical Society, March 17, 1890. — Light, Heat and Power.

† Experiments by F. C. P.

to the iron carbides, must have given off its dissolved oxygen long before reaching the region at which actual formation of hydrocarbons could occur. Hence, on this hypothesis, oxygen should be found in natural gas in larger quantity than the chemical tests indicate. In fact, in rocks of moderately high conducting power, a wide interval would exist between the depth at which the water boils and the much greater depth at which water vapor could oxidize metallic iron in quantity. It is doubtful whether water could have traversed this interval so as to reach the latter depth at all.

Engler (*Ber.*, vol. xxi., p. 1816, and vol. xxii., p. 592) has published the results of interesting investigations upon the distillation products of menhaden fish oil. By conducting the distillation at a high pressure (25 atmospheres), this author produced a mixture of hydrocarbon oils from which a large number of normal paraffins were obtained, compounds not found elsewhere in nature than in petroleum.

This has led to the revival of an older theory as to the origin of petroleum and gas, i. e., that they have resulted from the distillation under pressure and at low temperatures of the accumulated remains of marine life buried under the sediments of the ancient Devonian seas.

Much has been written in support of the hypothesis of Engler, and it may be said to have gained very general acceptance in Europe.

Oehsenius (*Chem. Zeitung*, 1891, p. 936) has summarized many of the arguments usually adduced in support of the hypothesis.

This author says: "Concerning the origin of petroleum, there is now no doubt that, with a few exceptions, animal remains (mainly of marine life) have yielded the raw material."

Originally the opinion was held that it was derived from vegetable matters, because the accumulation of animal remains sufficient to account for its formation by any distillation process in the rocks could not be explained. Distillation of vegetable matters would, however, have left greater deposits of coal (as a residue in the Devonian rocks). But petroleum occurs in rocks of marine formation where coal is uncommon. Rocks in which plant remains are found do not contain bitumen (petroleum). If animal remains are associated with those of plants, then bitumen is usually found.

The objection urged against the hypothesis of Engler, that nitrogen does not occur in petroleum, is easily overcome by the fact that nitrogen of animal tissues tends finally to produce ammonia, and this in the case of petroleum may have been carried away in solution by water; hence, the absence of nitrogen compounds.

From Engler's experiments, it appears that animal fats are the chief source of petroleum.

It is true that fatty matters do not ordinarily sink in water, although Von Guembel, in the voyage of the *Gazelle*, found fat globules in dredgings from the bottom of the Atlantic Ocean, in water 15,000 feet deep.

Putrefactive changes would tend to yield considerable quantities of ammonia and carbon dioxide. These in presence of salt water would produce alkali bicarbonate and ammonium chloride. Hence, alkaline waters might be looked for in the neighborhood of petroleum. The petroleum at Pechelbronn is associated with water containing 0.5 per cent. of alkaline carbonate. (In Western Pennsylvania many cases are known of water having a decided alkaline reaction in the neighborhood of gas wells. In Murrysville gas territory, water of alkaline reaction was so abundant as to seriously interfere with gas development.—Note by F. C. P.) Such alkaline waters are not known in archæan rocks, and are not, therefore, likely to be derived from greater depths than the rocks in which they are found.

Probably no cases can be cited where fatty tissues alone of buried animals have yielded oil or gas. The presence of strongly saline water is apparently needed.

Great differences occur in the chemical character of petroleum. Caucasian oils are mainly composed of olefines or substances related to the olefine group. The German oils are mixtures of paraffins and olefines, while the American are chiefly paraffins. Such differences may be attributed to the character of the rock in which the distillation has occurred. Sandstones will probably prove without action; while limestones, by reason of their basic character, would tend to strongly influence the products.

Such are some of the arguments of Oehsenius in favor of Engler's hypothesis.

If this view is accepted, it follows that the generation of petroleum and gas must be considered as a finished process, so far as all existing productive gas and oil regions are concerned.

Engler has analyzed the gas evolved when (1) menhaden oil and (2) when oleic acid are distilled under atmospheric pressure and under a pressure of 25 atmospheres.

	Menhaden Oil.		Oleic Acid.	
	1 atmos.	25 atmos.	1 atmos.	25 atmos.
Methane.....	25.2	38.3	9.3	4.36
Olefines.....	11.4	7.8	12.5	2.9
Carbon dioxide...	26.7	17.4	37.2	26.0
Carbon monoxide..	34.9	34.5	38.6	25.5
Incombustible residue.....	1.8	2.0	2.4	2.0

(*Ber.*, 1889, p. 592.)

The liquid distillates produced at the same time that these gases were evolved were rich in the normal paraffins and their isomers.

One hundred parts of menhaden oil yielded 8.9 parts of gas and 61 parts of liquid oils.

A strong argument in support of the Engler hypothesis is found in the fact that by distillation of fish oils, besides methane, several of the lower paraffins are produced in large quantity. Hydrocarbons of the paraffin series are not obtainable in such proportions by the distillation at high temperatures of other organic material under ordinary conditions.

It should be noted as a fact of much interest as regards the result of Engler's researches, that in the distillation at higher pressures the proportion of olefines contained in the gases evolved is considerably less. This is also true of carbon monoxide when oleic acid was distilled. It is to be regretted that Engler's experiments were not repeated at still higher pressures, in order to ascertain whether these same constituents

of the evolved gases diminish progressively with increased pressure.

Engler was the first to show clearly that the problem of the origin of oil and gas must be studied from the chemical rather than the geological standpoint. The hypothesis advanced by this author has been very generally accepted.

Nevertheless, my examinations of natural gas have led me to doubt some of his conclusions, well founded as they seem. The most careful tests, carried on during a period of six years, have failed to show the presence of either olefines or carbon monoxide in the natural gas of Western Pennsylvania.

Some of the constituents of gas are soluble in water. This is notably the case with carbon dioxide, butane, hexane, etc. If ethylene and carbon monoxide have been produced even in much smaller proportion in the rocks than Engler finds in menhaden oil gas, these substances would now occur in the natural gas of Pennsylvania. Ethylene would give to the gas such illuminating power that there would be no occasion for the use of coal gas in any town in the Western Pennsylvania gas region. As a matter of fact, natural gas is almost useless as an illuminant, its light being equal to 5 to 11 candles per 5 feet of gas consumed per hour.

Mr. Robert McKinney, formerly gas inspector of Allegheny County, found as a mean of forty trials of natural gas supplied to Pittsburgh an illuminating power of 6.5 candles.

Mr. J. W. Patterson, the present gas inspector of the county, states that the illuminating power of natural gas as supplied to Pittsburgh in November, 1892, is a little less than 11 candles per 5 feet per hour. The reason for this is that natural gas, as found in Pennsylvania, does not contain olefines. If carbon monoxide occurred in gas, there would have been innumerable cases of poisoning among workmen at gas wells. It is common to find such leaks of gas about the majority of gas wells that no one could strike fire at a well without risk of fatal consequences. Although inhaling the escaping gas for much of a lifetime, a gas well driller will usually maintain that no bad effects to health come from exposure to the gas. Air containing 92 per cent. of CO is known to produce dangerous effects upon health.

According to Wyss (*Zeit. Ang. Chem.*, 1888, p. 465), air containing 0.1 per cent. of water gas is poisonous to breathe.

It is hardly probable, moreover, that CO or C₂H₄, occurring in gas could have been absorbed or removed at low temperatures by any natural process in the rocks. Unlike carbon dioxide and ammonia, their slight solubility in water would preclude the supposition that they had been dissolved away. Muck (*Grundzüge und Ziele der Steinkohlenchemie*, 1881) cites analyses of fifty-seven samples of gas from coal mines and of gas occluded in coal. In only one case is carbon monoxide mentioned, but it is distinctly stated that its occurrence was not proved. Ethylene is mentioned in six cases, but Muck states that more recent analyses have failed to demonstrate its presence usually in gas from coal. The absence of hydrogen in all the analyses is especially noticeable. In the case of gases from the Caspian region, the presence of ethylene and carbon monoxide is to be anticipated, as, from all accounts, subterranean heat has been concerned in their production. (See table of analyses.)

Thomas (Watt's Dic., Third Supp., p. 529) gives analyses of fourteen samples of gas occluded by coal and also of gas from blowers in coal mines in New South Wales. The analyses showed the presence of methane, nitrogen, carbon dioxide and oxygen; but no carbon monoxide, hydrogen or ethylene was found. Franke (*J. Pr. Chem.* (3), xxxvii, pp. 101, 118) gives analyses of mine gases, according to which only carbon dioxide and methane were found. Winkler (*Jahresb.*, 1882, p. 1063) found no hydrogen in nine samples of mine gas. Many similar statements might be cited, all tending to prove that hydrogen, ethylene and carbon monoxide do not occur in gases occluded in coal.

The occurrence of gas consisting of nearly pure nitrogen, such as that obtained at Middlesbrough, England (see table of analyses), in a region, therefore, where gas similar to Pennsylvania natural gas might be looked for, may perhaps be explained by the action of subterranean water upon deposits of coal or bituminous shale. The dissolved air in such waters, by causing slow oxidation, might lead to the production of car-

and considerable quantities of olefines, together with hydrocarbons of still less saturated character. As a rule, the acetylenes and benzol series appear. Engler's hypothesis involves the supposition that a process of distillation has occurred at moderately high temperatures and at pressures measured by great depth of rock strata.

The carbon dioxide evolved in this destructive distillation must have come continuously into contact with the vast quantities of carbon, which in its various stages of transformation from vegetable tissue to anthracite is so widely distributed throughout the rocks. The reaction CO₂+C=2 CO, which proceeds rapidly at a strong heat and also slowly at lower temperatures, would then probably have occurred wherever the temperature was sufficiently high.

Prolonged contact of carbon dioxide with the carbonaceous residue of the distillation would perhaps be sufficient to increase considerably the final yield of carbon monoxide.

According to I. L. Bell ("Chemical Principles of the Manufacture of Iron and Steel," p. 101), the reduction of carbon dioxide to carbon monoxide by carbon in the form of soft coke begins at 427° C.

This is about the temperature at which Engler's distillation experiments were conducted (360°-420° C.).

Engler has shown that distillation of animal fats at very high pressure (25 atmospheres) may yield gas containing less of carbon monoxide and olefines than when the process is conducted under atmospheric pressure. No data are at hand as to results at still higher pressure.

If it is conceded that the proportion of carbon monoxide and ethylene in the gas evolved during destructive distillation decreases progressively with increase of pressure, and that these two constituents vanish altogether at sufficiently high pressures, it would still seem necessary to suppose that the pressure must have been at least twice as great when the process occurred in the rocks as in the case of Engler's experiments.

Taking the specific gravity of the rocks to be about 2½, it may be assumed that 12 ft. of rock strata represent a pressure of one atmosphere, 600 ft. of solid rock would then be required to produce a pressure of 50 atmospheres. This would be considerably less than the depth of the same quantity of rock material in the form of loose sediment, before its consolidation. No case can be cited in recent times where sediment 600 ft. deep has been so suddenly accumulated as to bury unchanged the vast quantities of animal remains necessary to account for the production of oil and gas upon Engler's hypothesis that oil and gas have resulted from the action of pressure and moderate heat upon animal matters.

There is probably no reason to suppose that the gaseous olefines have, under the influence of pressure, given place to others of higher boiling point, by a process of polymerization. Should the possibility of such a change be proved, the absence of olefines from natural gas and their presence in petroleum might be explained. The possibility of secondary reactions among the constituents of a complex gas mixture at high temperatures and under pressure adds difficulty to the problem, and caution is needed to avoid the error of overestimating the importance of any given reaction.

It is generally true, however, that under such conditions secondary changes are probable, and that unsaturated compounds—olefines, acetylenes, carbon monoxide—are likely to result, especially when water vapor and carbon dioxide are present.

It is a well-known fact that when petroleum is distilled, considerable quantities of unsaturated hydrocarbons are produced which did not exist in the original crude oil. This is shown by the bromine absorption of the different products. The process of "cracking" or breaking up by heat of the hydrocarbons in petroleum into simpler and less saturated compounds is familiar to all oil refiners. Chemically speaking, cracking means the production of unsaturated hydrocarbons.

The fact that Engler has, in his extremely interesting and important researches, produced by distillation of animal matters so great a variety of paraffins, constitutes by far the strongest argument in favor of his hypothesis.

Sorge, in an article which has been reproduced in numerous journals (*J. Ch. Soc.*, 1888, p. 31, abstract), has stated that a strong resemblance exists between Pennsylvania natural gas and gas manufactured from Westphalian coal. Similarity in composition between natural gas and coal gas would greatly simplify the problem of origin, and the fact of such similarity would prove of great interest.

In this connection, the following analysis of gas from Westphalian coal, carried out in the laboratory of the Westphalia Bergwerkskassens, in Bochum, will be of interest. I am indebted to Mr. Bergassessor E. Krabler, of Bochum, for the figures which he has kindly communicated by letter.

	1	2
Hydrocarbons, C ₂ H ₄	5	4
Methane	45	35
Hydrogen	40	50
CO	5	5
CO ₂	1	3
Nitrogen	4	3

The large percentage of hydrogen and the proportion of CO in this gas illustrate at once the results of high temperature in the production of coal gas, but a similarity between this coal gas and natural gas can hardly be said to exist.

When vegetable remains are buried under water, as is well known, decomposition occurs, yielding gas in considerable quantity.

Tappeiner (*Ber.*, 1883, p. 1734) has studied the products of this change very exhaustively.

Pure cellulose (filter paper) was found, under the influence of a microbe, which was supplied with nutritive fluids, to dissolve in water, yielding gas mixtures of two different types.

	Under Water of Neutral Reaction.		Under Slightly Alkaline Water.	
	At Beginning.	Per Cent.	At End.	Per Cent.
Carbon dioxide	85.48	76.98	55.39	
Hydrogen sulphide	0.0	0.0	42.71	
Hydrogen	11.79	23.01	0.0	
Methane	2.73	0.0	1.90	
Nitrogen				

From these experiments it appears that by the action of a microbe either methane and carbon dioxide (neutral fluid) or hydrogen and carbon dioxide (alkaline fluid) may result. Hoppeseyler (*Ber.*, 1883, p. 122) found that gas evolved in the decay of cellulose under the influence of a microbe (marsh gas fermentation) contained:

	Per Cent.
Carbon dioxide	50
Methane	45
Hydrogen	4

Popoff finds in a gas from decaying vegetable matters:

	Per Cent.
Marsh gas	68.56
Carbon dioxide	31.44

Berthelot states that hydrogen is produced in the vinous fermentation of mannite. In very careful experiments which I have tried I have failed to find hydrogen in the gas evolved during the fermentation of 300 grammes of sugar. Chemical changes of this type are not likely to be of importance, however, as regards the hydrogen question.

Gases from Sea Weeds.—The following experiments were tried in order to study the nature of the gases evolved in the decay of sea weeds:

A quantity of a large fucus kind from Santa Barbara, Cal., was used. Fifty grammes of the air-dried plant were soaked in water and then introduced into a flask filled with water which had been previously boiled (in order to expel air) and cooled. The flask was connected with a bell jar over a mercury trough. After setting up the apparatus, no gas appeared until the third day; then a strong evolution of gas began and continued in slowly diminishing quantity ten days, when the process ceased. In all, 803 cubic centimeters of gas were collected. Analyses were made (1) of the first portion of 300 cubic centimeters, (2) of a second portion of 300 cubic centimeters, and (3) of the last portion of 203 cubic centimeters. The results are tabulated below:

	First Portion Per Cent.	Second Portion Per Cent.	Third Portion Per Cent.
Carbon dioxide	18.23	32.47	53.44
Carbon monoxide	0	0	0
Ethylene	0	0	0
Methane	0.30	0.28	0.08
Hydrogen	62.24	48.97	42.92
Nitrogen	19.23	18.28	4.46
	100.00	100.00	100.00

Carbon dioxide was determined by soda solution over mercury; hydrogen by palladium asbestos, using a Hempel apparatus. The absence of CO and C₂H₄ was proved by palladium chloride solution. Methane was determined by combustion with air, using a red-hot platinum tube. The carbon dioxide produced in the combustion was absorbed by baryta solution of known strength, and the excess of baryta determined by standard oxalic acid. The following facts are of especial interest:

1. The carbon dioxide increases toward the end of the decay.
2. The hydrogen steadily diminishes.
3. Methane occurs only in traces.
4. Nitrogen occurs in such considerable quantity as to render it probable that this gas is set free in the process of decay.

The same apparatus was kept in position for 2½ years after the above experiments were finished. During that time a continuous production of gas was observed, but it was so slow that at the end of this period only about 30 cubic centimeters of gas collected. This was found to consist of methane.

I have examined the gases produced in swampy ground in many different places. Samples were taken from streams having muddy bottoms and in which vegetable matter had collected. Samples of gas have also been taken from salt marshes on the coast of Maine.

Gas has also been collected from the very deep accumulations of mud and decaying vegetable remains found in some parts of Lake Chautauqua. The general result of examinations of these gas samples may be stated to the effect that the gas occurring in shallow swamps and streams consists of methane, carbon dioxide, and nitrogen.

In some of the much deeper swamp waters, where masses of vegetable debris of greater thickness are found (as in Lake Chautauqua), hydrogen occurs in very small quantity. Great difficulty is experienced in taking samples of gas from localities of the latter type. Tappeiner observes that the marsh gas fermentation is probably a very important source of methane in nature.

The fact that buried vegetable matters may, after a brief period of rapid gas evolution, pass into a condition of extremely slow decay adds greater force to the original theory of petroleum and gas. The occurrence of so large a proportion of free hydrogen among the gases evolved by vegetation in process of decay is a matter of great interest, as it suggests the existence of an important source of hydrogen wherever deeply submerged plant remains occur. Frankland (*J. Ch. Soc.*, 1883, p. 295) found that grass left to decay under water (air being excluded) evolved gas in three days of the following composition:

	Per Cent.
Carbon dioxide	84.63
Oxygen	0.13
Hydrogen	6.90
Other combustible gases	2.51
Nitrogen	5.83

Vegetable tissue, after the somewhat sudden and tumultuous evolution of gas, seems to be capable of relapsing into an extremely slow and long-continued process of decay. After the first decomposition, such remains might become accumulated and buried deeply under sediments before the tissues are materially altered.

The generation of gas might proceed in the cold. It seems hardly possible to ignore this probable source of natural gas in discussing any theory as to its origin, especially when it is considered that no other process in nature has been found to yield a gas at all similar in composition to that found in the rocks.

Of the three hypotheses which have been proposed

CONSTITUENTS.	1	2	3	4	5	6	7	8
Carbon monoxide	0	0	0	0	0	0	0	0
Carbon dioxide	0.95	2.18	3.50	0	2.47	4.44	0	0.3
Olefines	4.11	3.36	4.36	0	0	0	0	—
Methane	92.99	93.07	92.34	95.39	97.57	95.56	1.04	—
Hydrogen	0.94	0.98	0	0	0	0	0	—
Nitrogen	2.15	0.49	—	—	—	—	96.57	96.8
Oxygen	—	—	—	—	—	—	1.53	2.9
	100.62	99.98	100.00	—	100.04	100.00	100.00	100.00

Nos. 1, 2, 3, 4, 5, and 6, natural gas from the Caspian region. Communicated by letter from Mr. M. Bellamin, of Nobel Brothers, St. Petersburg. No. 4 is the result of a partial analysis. Nos. 7 and 8 gas obtained by deep borings at Middlesbrough, England (*Bellon, J. Ch. Soc.*, 1888, p. 623).

bon dioxide and the consequent removal of oxygen from the water. The carbon dioxide produced would lessen the solubility of the water for nitrogen by causing the water to dissolve carbonate of lime, etc. Gentle heat from below would tend still further to the expulsion of the nitrogen, and thus a considerable but limited quantity of nitrogen might be obtained as a sudden outburst from a drill hole.

It may be said that varying conditions of temperature and pressure, and kind of rock, have modified the products, so that perhaps the carbon monoxide and ethylene resulting from a laboratory experiment have in nature's workshop given place to paraffins.

But if the chemistry of the reaction supposed to occur is to be considered at all, the fact that distillation experiments have produced from fish oil certain bodies found in natural gas (paraffins) should not count more forcibly as geological evidence than the other fact that such distillation yields bodies which are foreign to natural gas as usually found in Pennsylvania.

I have failed to find any data tending to show that organic matter can be subjected to destructive distillation in such a manner as not to yield carbon monoxide

to account for the production of oil and gas, two are open to a serious objection.

The chemical changes supposed by Engler to have been the cause would probably yield gas different in composition from the natural gas now being obtained in such large quantity in Western Pennsylvania, and if the gas originally contained ethylene and carbon monoxide, it is not easy to explain their complete disappearance in the natural gas I have examined from wells scattered over so large a region.

The hypothesis of Mendeleeff would be much more difficult to reconcile with the facts as regards composition. The total absence of hydrogen could not be easily explained. The only process in nature which is known to yield gas similar in its constituents to natural gas is that which occurs in swamps and decaying masses of submerged vegetable remains.

The important fact that the solid plant tissues may be preserved for long periods after the preliminary gas evolution has ceased shows that the remains are likely to become slowly buried, to undergo the fermentation changes leading to the production of methane.

Animal tissues can suffer no such arrest of decomposition. Decay once set in is carried rapidly onward to complete destruction without intermission. The contrast between the conditions in which animal and plant remains occur in the rocks seems to justify this statement.

If chemical evidence shall count in the discussion, it is difficult to find a more satisfactory explanation than the older hypotheses which the geologists advanced, although in their treatment of the subject the strictly chemical arguments were neglected.

[FROM NATURE.]

THE PLANET VENUS.

FROM time immemorial the planet Venus has attracted the attention of mankind. Before the days when the "optic tube" began to be turned toward her disk, Venus, we might say, was still in myth, and she was hailed as Hesperus and Phosphorus, according as she was an evening or a morning star, the fact that the same object was in question being then unknown.

Shining as she does at times with a brilliancy surpassing any other body except the moon, it is only natural that she should have been so often sung about by poets in all lands, liking her unto

"the fair star

That gems the glittering coronet of morn."

And she is highly honored by Homer, in that she is the only planet to which he refers:

"Ἑσπερος δὲ καλλίστος ἐν οὐρανῷ ἴσται ἀστὴρ."

Hesperus quæ pulcherrima in celo posita est stella.

To Galileo belongs the honor of first having viewed the planet through a telescope, but it is curious to remark the lapse of time that he allowed to pass before he made his first observation. The discovery that Venus exhibited phases did not take place until the end of September, 1610, though Galileo first observed the satellites of Jupiter on January 7 of that year.

That Galileo should veil this important discovery of the phases of Venus under a Latin anagram* does seem at first rather strange, but when one considers the vast importance of the discovery in that it supplied a simple proof of the planet's revolution round the sun, one can understand that he would first desire to be quite certain of his facts before giving the key to the anagram.

An historical fact of interest with reference to Father Castelli may be mentioned here. In Venturi's collection there is a letter from Father Castelli to the celebrated Florentine astronomer, dated November 5, 1610, in which he asks Galileo whether Venus and Mars show phases. Galileo evidently did not wish to give a direct answer, so evaded the question by saying that, although he was engaged in various investigations, he was better in bed than out in the open air in consequence of great infirmity. It was not until December 30, 1610, that he informed Castelli of his recognition of the cusps.

With an ever-increasing number of telescopes at the disposal of astronomers, it is not astonishing that facts concerning surface markings, form, period of rotation, etc., should be rapidly forthcoming, and the sum total



FIG. 1.—February 26, 1878 (Trouvelot).

of what we now know about the planet has been gained at the expense of much labor and patience at the eyepiece end of the telescope.

During the past three months Venus has been a striking object in the southwestern and western region of the sky, being in a position more than usually favorable for observation. Toward the end of November last her great southern declination began to decrease, while the planet became brighter and brighter, passing her greatest elongation east on December 6. On January 11 she attained her maximum brilliancy, the crescent form gradually increasing until on February 13, that is, at inferior conjunction, it was totally invisible. Gradually the crescent will become visible

* "Hæc immatura a me jam frustra legentur," or with the letters properly arranged—"Cynthia figuræ simulacrum Mater Amorum."

again, but in the inverse order, and we shall have another maximum on March 23, superior conjunction occurring on November 30. Thus we know that Venus is now lost in the sun's rays, and is, in consequence, invisible to us as evening star for some time to come. The accompanying illustration (Fig. 1) gives a drawing of the planet as recorded by Trouvelot in 1878, at a time when only a very fine crescent was visible. (The bulging at the south-southeast portion of the crescent was observed, and is not a defect in the drawing.)

Of all the planets, Venus approaches us the nearest, her minimum distance amounting sometimes to approximately five million miles, that is, about five times nearer than when she is furthest from us. Unfortunately, at these times her illuminated disk is turned away from us, and all we can do is to direct our atten-



FIG. 2.—Details of Snow-caps January 19, 1878 (Trouvelot).

tion to the small crescent that remains before inferior conjunction is reached. This accounts for the uncertain knowledge that we possess with regard both to surface markings and the period of rotation. The latter question is still a moot point among astronomers, and it is interesting to note the historical sequence in which these investigations have been made. The first spots on the planet's disk were noted by Dominique Cassini in October and June of the years 1666 and 1667 respectively, and from them he deduced a period of 23 h. 21 m. Bianchini, about 60 years afterward (1726-27), came to quite a different result, substituting 24 days 8 hours for that obtained above. Jacques Cassini, discussing his father's observations and those made by Bianchini, concluded that a period of 23 h. 20 m. satisfied both the old and new observations, but that Bianchini's value would not agree with that of his

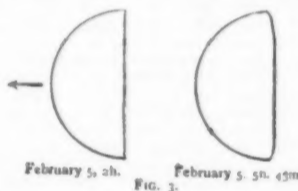


FIG. 3.

father. This value seems for some time to have been accepted, and Schroeter's (1798-99) and De Vico's (1840-42) observations practically confirmed it. Fig. 2 gives a view of the planet as seen on January 19, 1878, and shows the details in the polar spots sometimes available for "period of rotation" determinations.

Thus matters stood till that keen-eyed observer Schiaparelli took the field. After a most careful study, extending over many years, in which some single observations were made extending over eight consecutive hours, he was led to make the statement that the rotation of the planet is exceedingly slow, and probably takes place in a period of 224 days 7 hours, the duration of the revolution of Venus about the sun. At Nice, M. Perottin has come to a similar view, expressing his opinion in the following words: "Ne diffère pas de la durée de la révolution sidérale soit 225 jours environ, de plus de 30 jours." These two observers, especially

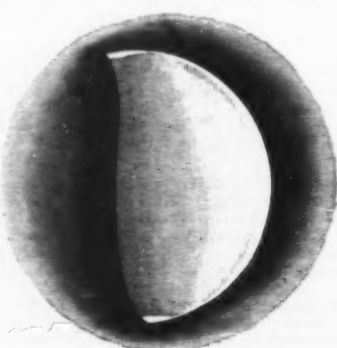


FIG. 4.—Showing Irregularity of Terminator November 23, 1877 (Trouvelot.)

the former, thus upset our whole belief in a short duration of the period, but we are still again brought to consider the question from observations emanating from another source. We refer to those made by Prof. Trouvelot (see *Nature*, vol. xlii, p. 470), whose opinion is of great weight.

The importance of his work lies in the fact that it was carried on at the same time as that of Schiaparelli "souvent dans la même journée, sous un ciel également propice et précisément sur la même point de la planète." The value ultimately deduced was 23 hours 49 minutes 28 seconds, which again brings us back to a short period. In referring to Schiaparelli's observations he says: "La cause probable de l'erreur de M. Schiaparelli semble résulter de ce fait que les taches h et k, qui

ont servi de base à ses conclusions, faisaient partie de la tache polaire méridionale qui, étant située centralement sur l'axe de rotation de la planète, semble rester stationnaire, comme cela se voit sur la tache polaire de Mars, quand elle se trouve réduite à de faibles dimensions." He also refers to the general features visible on the planet's surface as indications of a rapid rotation, especially that of the rapid deformations of the terminator and hours.

Thus we are left with the choice of two periods, one long and consisting of 224 days, the other short, of 24 hours nearly. We leave our readers to adopt that which they think best, the balance of favor falling, in our opinion, slightly toward the 24 hour side of the scale. But just as Schiaparelli's observation of the doubling of the canals of Mars was finally observed and universally accepted, so perhaps time may prove his case as regards this period of rotation.

Some of the most recent work on the planet Venus relates to the measurement of her diameter. Among a few of the reduced measures the following may be given: Hartwig, with the Breslau heliometer, from forty-three observations obtained a diameter of 17".67. The same observer, from a reduction of the Oxford observations, and also from Kaiser's observations with Airy's double image micrometer, obtained 17".582 and 17".409 from thirty-three and thirty-four observations, respectively. Auwers from the transit of Venus measures deduced the value 16".801, while Auwers, from thirty-four observations, measured the diameter as 17".711.

Among other interesting points to which we might refer are the planet's visibility in full daylight, the snow caps, the secondary light, the planet's form, etc. Each of these has raised a host of questions at various times, which even yet are not fully answered. The question as to the form of the planet itself is also one full of interest, and observers, from Beer and Madler down to Trouvelot, have made numerous drawings of the different appearances. Observations have shown that the surface, or whatever it is that we look at, is by no means level, but extremely uneven or irregular. Such irregularities can be best detected naturally at the terminator and limb. Fig. 1 indicates a bulging at the limb, while Fig. 3 shows a similar phenomenon at the terminator at two different times—February 5, 2 h. and 5 h. 43 m. (Perhaps this is one of the best proofs of a "short duration" period for rotation.)

Fig. 4, which we also owe to Prof. Trouvelot, shows a more decided case of irregularity, and on perhaps a much larger scale.

Much remains, however, to be done before we are on anything like a footing with this planet as we are with Mars. With this latter we can observe directly the land and water markings, time to a second the period of rotation, observe local storms, and many other details; but with the former the case is different. Here the planet is for the most part lost in the rays of the sun, or at other times not very easy for observation.

That Venus has an atmosphere is a fact which has long been known, and that this is denser than the earth's envelope is also very probable. The part this atmosphere plays in the determination of the period of rotation seems to be of great importance, and it is rather a question of whether we have been observing real rigid markings on the planet itself, or only what has been described as "a shell of clouds, the appearances interpreted to signify the existence of lofty mountains, snow caps, vast chasms, and crater-like depressions, are really nothing but the varying features of cloud scenery."

Whichever the case may be, future observation has still to show; but it seems that with the rapid advance now taking place in large instrument making, such a question as this could be settled, given a few fine evenings or mornings near a favorable time of observation, a clear and still air, and a large aperture. Such occasions, perhaps, may be rare, but the point at issue is important, and should be settled as soon as possible.

W. J. L.

THE MEGALADAPIS.

A GIGANTIC LEMURID RECENTLY DISCOVERED IN MADAGASCAR.

THE great African island of Madagascar, the area of which exceeds that of Italy, is, like Australia, a true continent, or rather the remains of one, very distinct in its fauna from Africa, of which it is so close a neighbor from a geographical point of view. This fauna is especially characterized by the presence of numerous Lemuridae or makis, quadrumanous mammals, called also lemurs and false or fox-nosed monkeys, and which here replace the true monkeys that are so numerous in Africa. We find, indeed, a few Lemurids in Africa and in Malaisia, but they seem to be isolated there, and as if lost in the midst of a fauna of an entirely different character. In Madagascar, on the contrary, they form two-thirds of the mammiferous population, and it cannot be doubted that they are located in their true country.

We find also on this island a very curious cat, the *Cryptoproctus*, which is a plantigrade, while all the other cats distributed throughout the entire world, with the exception of Australia, are digitigrades. Finally, Madagascar is destitute of indigenous ruminants.

These zoological peculiarities give this island a feature of oddness almost as great as that which distinguishes Australia. In order to find a fauna comparable with that of this island we must go back to the ancient geological ages and examine the fossils that characterize them. We find, then, not without surprise, that in Eocene and Miocene times, that is to say, at the beginning of the great tertiary period, animals similar to those that still live in Madagascar stocked the forests of the country now called France. The Carnivore, whose remains are found in the Eocene of Quercy and the Miocene of Saint-Gerard-le-Puy, and which Mr. Filhol has named *Proailurus*, scarcely differ from the *Cryptoproctus* of Madagascar. So, too, the small mammals that existed at the same epoch in France, and whose bones have been described under the names of *Adapis* and *Necrolemur*, were tree-inhabiting quadrumanous very nearly akin to the makis of Madagascar, in a word, true Lemurids. Such approximation is not one

* See *Astr. Nachr.*, No. 3304, p. 190.

of the least surprises that science has prepared for us. Thus Madagascar has, up to the present epoch, preserved an Eocene fauna, just as Australia still possesses a Cretaceous, that is to say, secondary one. From what has just been said, it will be seen how interesting it would be to know the geological faunas that preceded that which still exists in Madagascar. These ancient faunas, however, are almost entirely un-

paleontologist, has described under the name of *Megaladapis Madagascarensis*.

As well known, the Lemuridae that now inhabit Madagascar are all small or of medium size. The largest of them, the short-tailed indris (*Indris brevicaudatus*), called by the Malgaches "man of the woods," and which we represent herewith (Fig. 2) for the sake of comparison, attains scarcely three feet in

front, although the cavity of the orbit communicates widely behind with the temporal fossa, this distinguishing them from the monkeys, in which this communication is closed, as in man, by the consolidation of the frontal bone with the sphenoid and malar bones. Besides, the lachrymal duct is situated outside of the orbit, and not within, as in man and the monkeys. Notwithstanding the elongation of the muzzle, the dentition is quite similar to that of the American monkeys, but the lower incisors point outwardly and are sometimes reduced to two, as in the indris. The dentition, moreover, varies much from one genus to another, and the adult, through the effect of age, often loses one or more pairs of teeth that are present in the young, so that the dental formula of the latter is always more normal than that of the adult.

The *Megaladapis* presents the cranial and dental character of the Lemuridae, but modified in a very special manner and of which no example is known among the living species.

What strikes us at first sight when this skull is examined alongside of that of other Lemuridae is the narrowness of the cerebral case, which seems out of proportion with the elongation of the facial region, and the strength and heaviness of the jaws. The present Lemuridae have, indeed, an elongated muzzle (like that of a fox), but their skull is always much more rounded and inflated behind than that of the *Megaladapis*. The cerebral cavity of the latter is no more than three inches in length, so that the brain of this large Lemurid was no larger than a hen's egg. It is the ordinary size of the brain of the indris, whose skull is three times shorter. Now, it appears that the indris possesses only quite a moderate amount of intelligence. If we admit that the intelligence is always proportionate to the development of the brain, we may conclude therefrom that the *Megaladapis* was a pretty stupid animal. On the contrary, it must have possessed great muscular strength. The skull that we have before us must have afforded an attachment to powerful muscles. The sagittal crest that occupies the summit of it, the very large zygomatic apophyses, the deep temporal fossa, and the size of the teeth are an evident proof of this. In its entirety, this skull recalls that of the large monkeys, such as the baboon, the chacma, and the mandrill, the stature of which approaches that of the anthropoids and which have also a greatly elongated head and a huge jaw, which has given them the name of *Cynocephali* or dog-headed monkeys. The *Megaladapis* was a cynocephalous or dog-headed Lemurid, at least at the adult age, for, like the monkeys, the young must have had a more rounded skull and borne more resemblance to

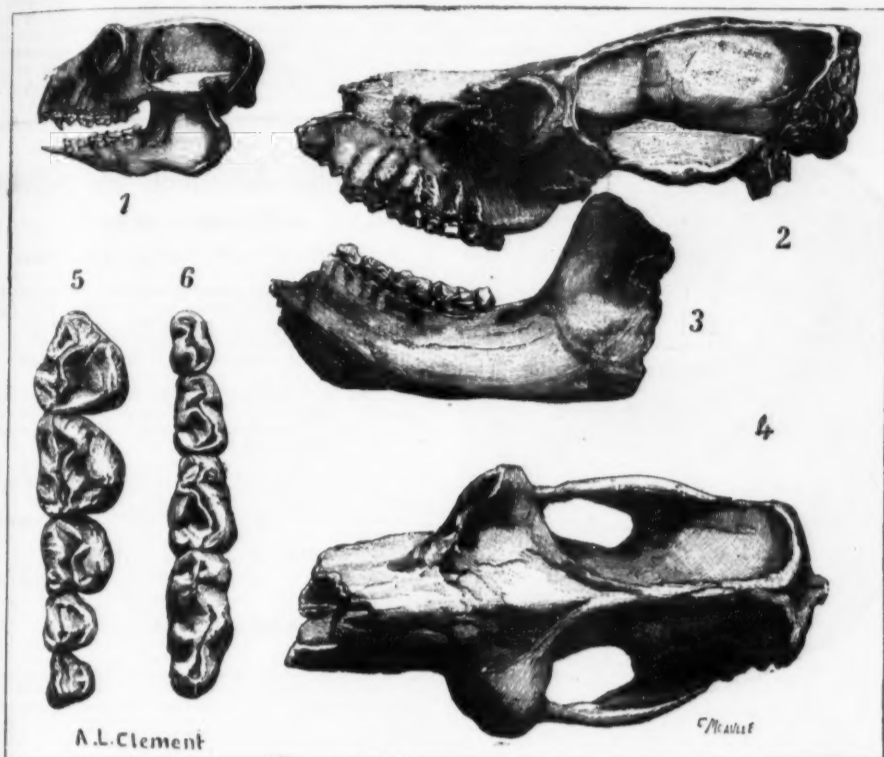


FIG. 1.—SKULLS OF THE INDRIS AND MEGALADAPIS.

1. Skull of indris ($\times \frac{1}{3}$). 2 and 3. Skull and lower jaw of megaladapis ($\times \frac{1}{3}$). 4. Skull of megaladapis seen from above. 5 and 6. Upper and lower tooth of the same (of natural size).

known to us, despite a few isolated discoveries well calculated to excite the zeal of paleontologists.

In 1851, in fact, that is to say, more than forty years ago, there were discovered in some relatively recent strata in Madagascar some eggs of huge size (of a capacity of two gallons) along with the bones of a bird that must have laid them, and which Geoffroy Saint-Hilaire designated with the name of *Aepyornis maximus*. It was an *Apteryx* nearly ten feet in height, the most massive of all known birds, since in this respect it exceeded the *Dinornis*, which was more slender. In the same strata were discovered later on the remains of a hippopotamus (*Hippopotamus Lemerlei*) different from those that exist in Africa. This is about all that we know concerning the ancient fauna of Madagascar. A long interval had to elapse before any new discoveries should be made. Very recently, however, these paleontological researches have been resumed with new ardor, and this time with more encouraging

height when it stands upright upon its hind feet. Its skull is no larger than that of a fox.

The *Megaladapis* was three times larger, thus giving this great Lemurid the stature of the orang-outang or gorilla, but with a very different aspect and very different proportions, according to all appearances.

In Fig. 1 we represent the skull of this animal reduced to a third of its natural size. Alongside of this is placed the skull of the indris reduced to the same scale, thus permitting one to obtain an idea of the real dimensions of the *Megaladapis*. The teeth of the latter are figured of natural size. It will be seen that they are stronger than those of man and comparable to those of the gorilla. Finally, the head of the indris, a front view of which of natural size is shown in Fig. 3, gives us an idea of the physiognomy that a Lemurid three times larger must have possessed.

The skull of the *Megaladapis* is 8 inches in length,



FIG. 3.—HEAD OF INDRIS (Natural size).

the other Lemurids. The orbits of the *Megaladapis* are remarkable by their form, being quite different from that of the makis. The latter, almost all nocturnal, have very wide orbits directed outwardly, almost touching upon the median line. Here, on the contrary, the orbits are very wide apart, and lateral or directed obliquely, forming a sort of funnel—an arrangement found again, up to a certain point, in the indris. The eye of the *Megaladapis*, instead of being large and prominent, as in the present Lemuridae, must have been sunken and protected by the orbital frame, a conformation that indicates habits less truly nocturnal than those of the present Lemurids.

The teeth of the upper jaw (the three premolar and three posterior molars) all have three tubercles, two external and one internal, but it is easy to see that this latter is formed by the fusion of two tubercles. This, however, is quite common in the Lemurids, some of which have molars with four tubercles, as the indris, while others, and particularly certain species of small size (of the genera *Lipilemur* and *Cheirogaleus*), have but three. As in these small species, the *Megaladapis* presents a last molar as strong as the one next to the last, while the posterior tooth is notably reduced in the indris and the makis properly so called. The lower molars are of the ordinary four-tubercled type, except the last, which has five tubercles and is much elongated in consequence of the presence of this fifth tubercle, forming a spur. This lower posterior molar, elongated and with five tubercles, is observed in the *Lipilemur* and in the fossil *Adapis*. It exists also in the cynocephalous monkeys, in the *Oreopithecus*, a large monkey of the tertiary of Italy, and is found again in the omnivorous ungulates of the group of hogs.

The front teeth are wanting in the upper and lower jaw which we figure and which are fractured at the point of insertion of the canines. From an examination of what remains, it is probable that these canines were of middling size, as in most of the Lemurids. The form of the symphysis of the lower jaw, which is very high and very strong, proves that the lower canines and incisors were almost straight and not slanting like those of the indris and other Lemurids.

The *Megaladapis* presents several points of resemblance with the *Adapis* of the tertiary of France, particularly with the *Adapis magnus*. Such are the presence of a sagittal crest and the form of the orbits and that of the teeth of the lower jaw, etc.

This type undoubtedly belongs to the order of Le-

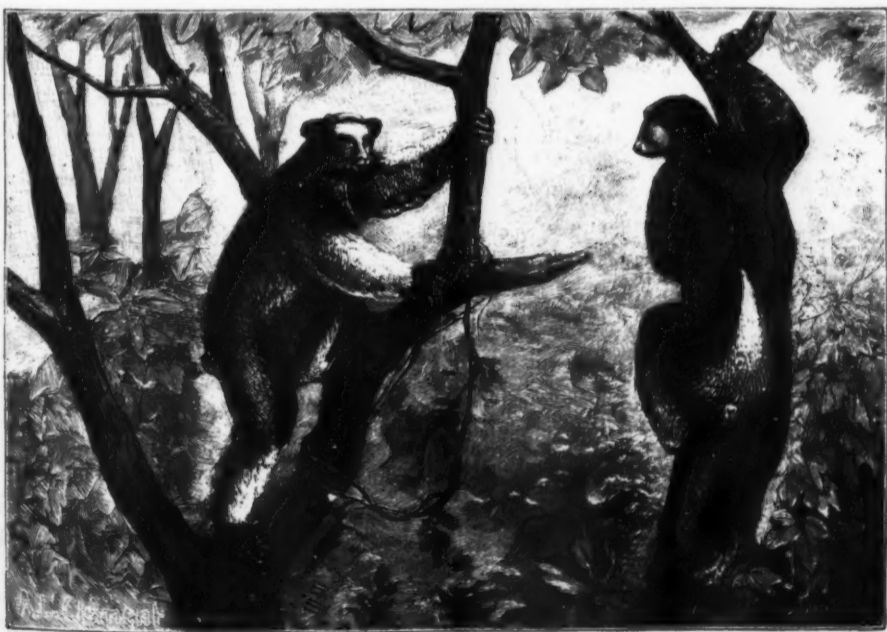


FIG. 2.—SHORT-TAILED INDRIS OF MADAGASCAR.

results. The fossil remains that are found, especially in the ancient, partially dried marshes that abound in certain parts of Madagascar, are very abundant, and it seems as if the study of them ought to throw an entirely new light upon the ancient fauna of the great island of the Indian Ocean.

The most remarkable of such remains is the nearly complete cranium of a large Lemurid of an extinct species, which Mr. Forsyth Major, the well known

and, as the anterior part is broken, it will be seen that the head of the living animal must have exceeded that length. The width at the orbits is $4\frac{1}{4}$ inches. The last upper molar is more than 7-10 of an inch in its greatest diameter, and the corresponding lower molar, which is greatly elongated, is more than an inch in diameter.

The Lemuridae of the present epoch are characterized by their orbital frame forming a complete circle

murids, but, with Mr. Forsyth, we think that it ought to constitute a family apart, akin to but distinct from that of the present Lemuridae. In every respect, it is a very specialized type, which, after it has become better known, will doubtless form a new link connecting the Lemurids with the Ungulates. We know that Mr. Milne-Edwards has shown that the makis, by their internal organization, are closely related to the Suidae, and we may recall the fact that Cuvier described the *Adapis* as a small ungulate akin to the daman. It is not impossible that the *Megaladapis* was a Lemurid on the way to a transformation toward the type of the Ungulates, the same as the aye-aye or *Cheiromys* is a Lemurid that is becoming transformed under our eyes into a rodent.

The skull of the *Megaladapis* came from the same marsh of Ambolisatra in which not long ago were found the remains of the *Pygornis* and hippopotamus of which we have already spoken. The geological strata are of recent origin, for we find therein the bones of the domestic ox introduced into Madagascar by man. All the bones have that modern aspect which paleontologists characterize by saying that they are subfossil, and several exhibit traces of the hand of man.

The *Megaladapis* has however a well-marked tertiary aspect, and this is the first time that a fossil mammal so different from all the mammals now living has been found in Madagascar. We can scarcely doubt, however, that this large Lemurid lived at a relatively recent epoch, and was hunted and eaten by the first men who introduced the domestic ox into Madagascar.

What gives much weight to this opinion is the following passage from Flacourt, the first historian of the great African island, and which seems to refer to the *Megaladapis* or to some large Lemurid closely related to it:

"The tretretrete, or tratratra, is an animal as large as a two-year-old calf, and which has a round head and a man's face; the fore-feet like those of a monkey, and the hind ones also. It has curled hair, a short tail and ears like those of a man. It resembles the tannche described by Ambrose Pare. It has been seen near Lake Lipomani, in the vicinity of which is its lair. It is a very solitary animal that the people of the country hold in great fear and run away from, as it also does from them."

With the exception of the round head and the size, which is doubtless exaggerated, this description by Flacourt applies to the *Megaladapis* very well. If we reflect, moreover, that the head of the living animal must have been covered with one of those shocks of curled hair which, in the present Lemurids, greatly increase the volume of it behind the ears, it will be agreed that there exists at least a singular coincidence between this description and the discovery recently made in Madagascar. The data given by Flacourt as to the fauna of the island are, as a general thing, very accurate, and most of the animals that he describes have been found by the naturalists who have succeeded him. It is therefore permissible to believe that rare survivors of this large species of Lemurid were still living, "very solitary," as he says, at the epoch of his sojourn in Madagascar—that is to say, in the middle of the seventeenth century.

However this may be, an examination of the skull of the *Megaladapis* permits of representing the latter as a Lemurid of a size comparable to that of a mandrill, and, like the latter and the indris, destitute of a tail. Like the cynocephalous monkeys, it must have inhabited mountainous and rocky districts and have oftener remained upon the ground than in trees. It ascended the latter only to obtain its food, which must have consisted of small birds, leaves, and fruit. Its strength must have been very great, and when it was attacked, its teeth and its robust arms must have rendered it formidable to man himself. But its intelligence was of a low order, so that it was easily exterminated by the population (probably of Malaisian origin) that colonized Madagascar, and that seized every opportunity of killing it with spears and *sagaites* in order to feed upon its flesh. We can wait to soon possess new data in regard to this large Lemurid and to the other mammals, now extinct, that constituted the tertiary fauna of Madagascar. Among the bones recently sent from this island to the Museum of Paris, and a description of which will be given by Mr. Milne-Edwards, there is a humerus that might well have belonged to the *Megaladapis*.—E. Trouessart, in *La Nature*.

ACTION OF LIGHT ON BACTERIA.†

By Prof. H. M. WARD, F.R.S.

A THIN film of gelatine or agar, in which spores or bacteria are evenly distributed, is spread over the flat bottom of a shallow glass dish. The lid of the dish is a plate of ground glass, in which one or more slots, about $\frac{1}{2}$ inch wide and $2\frac{1}{2}$ inches long, are pierced. The spectrum is so arranged that the light rays fall perpendicularly on the film carrying the spores, etc., and can only reach the latter through the slots, all other parts of the plate being covered by tin foil and black paper.

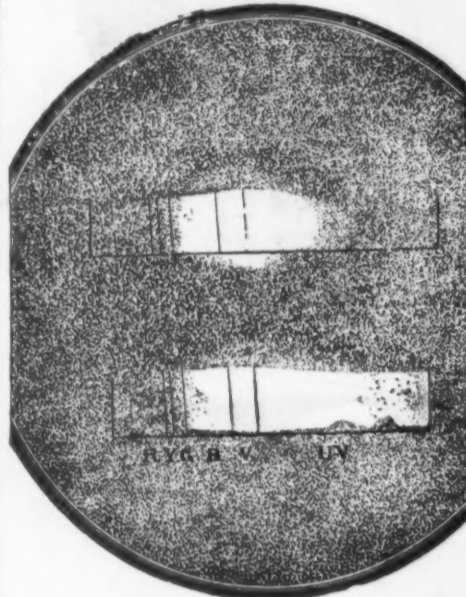
When the film has been thus locally exposed for a certain number of hours to the spectral rays, the culture is put into the incubator. All those parts protected from the light entirely behave as in any ordinary culture—the spores germinate out and develop colonies, and the previously transparent film (transparent because the spores are too minute to affect it) becomes opaque.

Under the slot, however, the spores were exposed to the various rays of the successive regions of the spectrum. On one part of the exposed area the infra-red rays fall; on another the red, on another the orange, and so on with the yellow, green, blue, violet, and ultra-violet rays.

If any of these rays kill or injure the spores they fall on, obviously the latter will show the effect by not germinating at all in the incubator, after exposure, or by germinating more or less slowly and feebly in comparison with the uninjured spores.

Wherever the spores do not germinate at all, the gelatine remains transparent; where they only germinate and develop into slowly growing, feeble colonies, the transparency of the gelatine film is merely clouded more or less; whereas where they germinate and develop as vigorously as on the unexposed parts of the film, the latter is rendered quite opaque.

Obviously these differences, or contrast effects, can be photographed, and the following is a photograph of a plate treated as described.



ACTION OF LIGHT ON BACTERIA.

In all cases so far examined, both the solar and electric spectra show that no action whatever is perceptible in the infra-red, red, orange, or yellow region, while all are injured or destroyed in the blue and violet regions.

The exact point when the action begins and ends is not the same in all the experiments, though very nearly so, but it must be reserved for the detailed memoir to discuss the various cases.

Broadly speaking, the action begins at the blue end of the green, rises to a maximum as we pass to the violet end of the blue, and diminishes as we proceed in the violet to the ultra-violet regions.

Some especially interesting results were obtained with the electric spectrum. In the first place, the results with glass prisms, lenses, etc., were so feeble that it was necessary to employ quartz throughout.

Secondly, the bactericidal effect is found to extend far into the ultra-violet. The intervention of a thin piece of glass results in the cutting off of a large proportion of effective rays.

These results suggest evidently that the naked eye light may prove to be a very efficient disinfecting agent in hospital wards, railway carriages, or anywhere where the rays can be projected directly on to the organism.

THE ACARI.

AT the recent annual meeting of the Royal Microscopical Society, Mr. A. D. Michael, president, delivered the annual address. He took for his subject the growth and present state of our knowledge of the Acari. The name "Acarus" was probably first used by Aristotle; it means uncuttable. But Aristotle did not anticipate Cambridge rocking microscopes, and the president exhibited a set of over 120 serial sections cut from a far smaller Acarus than Aristotle could ever have seen. The president then described what an Acarus really is and in what respects it differs from other Arachnida, a distinction which is erroneously stated in almost all text books of zoology. The classification of the group practically began with Linnaeus; it was shown how difficult it is to identify a Linnaean species, and the progress of classification was shortly traced from the single Linnaean genus to the two hundred and twelve genera admitted by Trouessart, one of the latest writers on the subject. The president then referred to the fact that many of the predatory Acari had not any special organs of vision, and yet that they were most active creatures, and would catch such agile insects as Thysanuridae without constructing any web or trap, and did not seem to suffer in the least from their eyeless condition; he had seen small and weak Acari quietly waiting until large ones had finished feeding before they ventured to attack the leavings, although both were blind. The various forms of acarine parasitism and commensalism were then described, including one where a parasite lives in the fur of the rabbit, not feeding on the host, but on other parasites which really do so, and the number of these which it will destroy is amazing. The president then illustrated the principal families of Acari by selecting one or two instances of each, which were especially interesting either from their habits, their anatomy or otherwise. The Sarcopitidae, or bird parasites, were represented by a parasite of the cormorant, discovered by the president, in which the male has one leg much larger than the other; and the skeleton of the body is greatly modified to support it; but the enlarged leg and modified skeleton are on the right side of the body in some specimens and on the left in others. The so-called cheese mites were referred to in order to describe the hypopus stage in the life history of many of them; when the creature, which is originally soft and easily killed by heat or exposure, suddenly becomes hard and able to endure almost all vicissitudes, and also to live for a long period without eating; it is then provided

with special organs for adhering to insects, and the species are widely distributed under circumstances where they would otherwise perish. The president then spoke of his recent researches into the association between many Acari (Gamasids) and certain ants whose nests they live, and of a still stranger and hitherto unrecorded case, even more lately observed by him, in which a species of Acarus (*Bdella*) lives habitually in a spider's web in harmony with the otherwise most ferocious occupant. The speaker then shortly described his recent discovery of the extraordinary way in which female Gamasids are fertilized, a spermathecal capsule being conveyed to its destination by the mandibles of the male. Finally, the descent of the Acari was discussed.

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* De Flacourt, *Histoire de la grande Ile de Madagascar* (1698), p. 154. As to the "tanache," or rather "thanach," of Ambrose Pare, the description of which is found in the book on *Des Monstres tant terrestres que marins, avec leurs Po-traites*, the passage that refers to this animal is marred by fabulous traits that we are surprised to find coming from the pen of the great surgeon, so full of learning and good sense in the rest of his writings. We see, nevertheless, that it is a question of a large anthropoid monkey, probably of a chimpanzee, carried on board of a ship commanded by Andre Thonet in his voyage through the Red Sea. (Cf. A. Pare, *Œuvres Complètes*, Maligne edition, 1840, t. III., p. 786.)

† Lately read before the Royal Society.—*Nature*.

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